New Scientist

WEEKLY 5 February 2022

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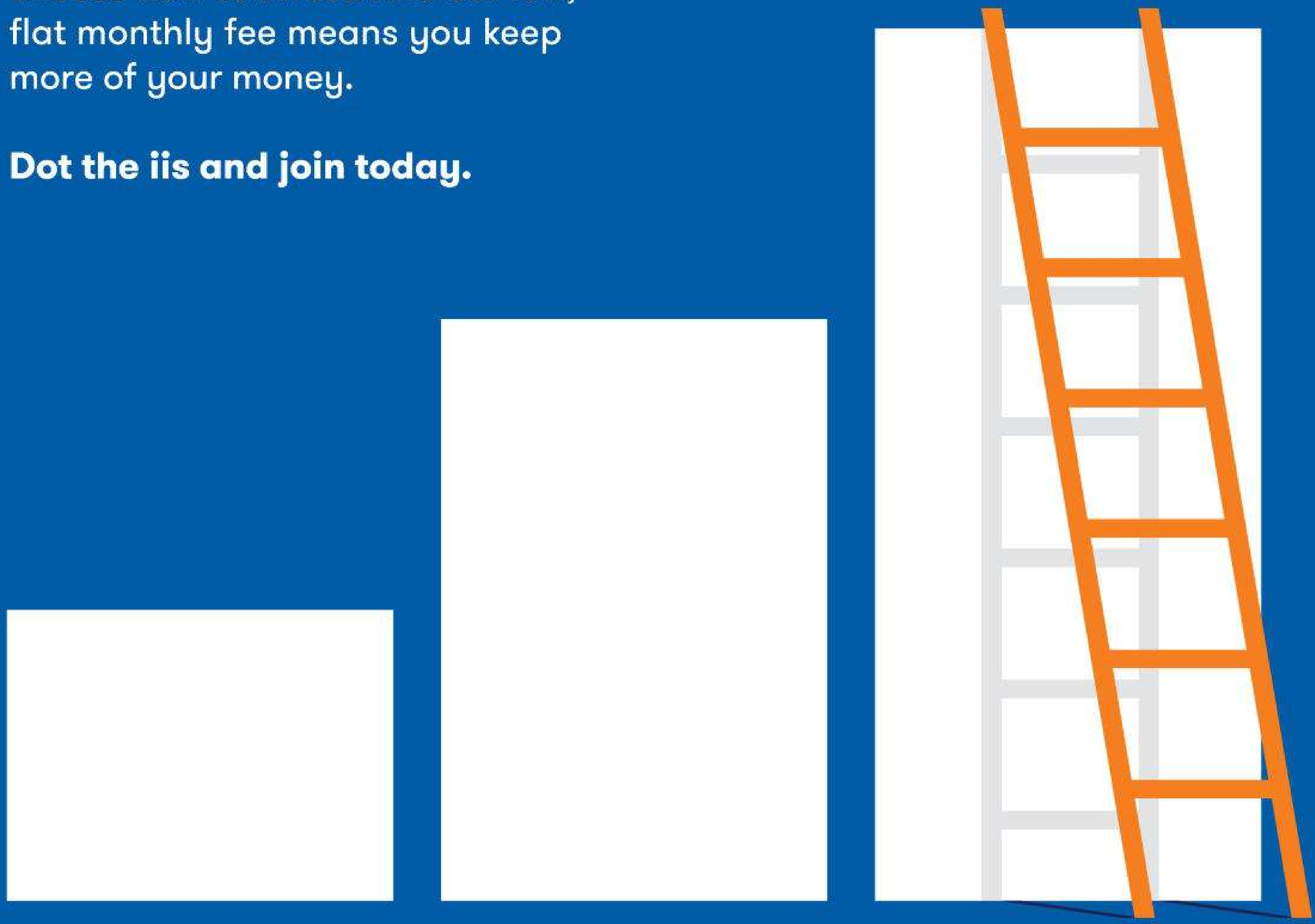

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New Scientist

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Event

True crime, forensics and psychopaths

Join psychopath expert Mark Freestone, who helped shape the character of Villanelle for TV show *Killing Eve*, and forensic chemist Niamh Nic Daeid, who has advised crime writer Val McDermid, for a darkly compelling evening of crime science. This event is at London's Conway Hall on 16 March. Doors open at 6.30pm GMT.

newscientist.com/events

Discovery Tours

Kenya, the cradle of humanity

Explore the origins of our species and see incredible wildlife on this unique holiday to Kenya. Hosted by palaeontologist Louise Leakey, you will visit important archaeological sites and get a private tour of the Nairobi National Museum. This is a 10-day trip starting on 1 June.

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Podcast

Weekly

The team explains how covid-19 can cause neurological conditions, from strokes to muscle weakness and brain fog. Plus, we are living through a geological epoch called the Anthropocene, but when might the name be made official? What's more, your host Rowan Hooper returns from Norway with a story about melting glaciers in the Arctic.

newscientist.com/nspod

NASA/JOHN SONNTAG

Going, going... How quickly are Svalbard's glaciers melting?

WILLIAM LUDT/JOURNAL OF FISH BIOLOGY

Light fantastic The Pacific footballfish can illuminate the deep sea

Video

How to clean up a river

Sewage, agricultural waste and plastic are polluting waterways and reducing fish and insect numbers. In our latest video report, we visit the Evenlode river in southern England where a utility company, local farmers and volunteers are using simple tricks to boost the water quality (see also p23). For more videos, don't forget to subscribe to our channel.

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Newsletter

Wild Wild Life

Get Penny Sarchet's newsletter about the wonders of animals and plants delivered free to your inbox. This month, she gives some tips on how to understand the world of plants and marvels at the Pacific footballfish, which lives in the deep sea and can light up its surroundings in two different ways.

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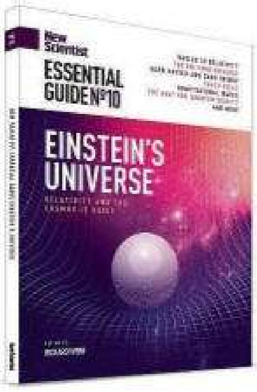
Newsletter

> **"This fish can biofluoresce, a rare skill that has never been documented in anglerfish until now"**



Essential guide

How did the universe begin? What is it made of? Do black holes exist? Albert Einstein's space- and time-warping theories of relativity have revolutionised our view of the cosmos over the past century. Find out how in the 10th *New Scientist Essential Guide*, available now.

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GDF

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Debate

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THE UK'S NUCLEAR WASTE AND THE GEOLOGICAL SOLUTION

Wednesday 23 February 2022 6pm GMT, 1pm EST and on-demand

The UK Government has decided that higher activity nuclear waste should be disposed of in a deep underground facility where scientists believe it can remain safe for the long term. Numerous countries have come to the same conclusion and work has already begun to create safe, secure and permanent disposal facilities elsewhere in the world.

This *New Scientist* debate brings together leading thinkers to explore the science behind the geological disposal of nuclear waste, examine the engineering, economic and social challenges at play and asks how similar projects elsewhere are faring.

Find out more and register your place:
newscientist.com/nuclearwaste

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Katherine Morris
BNFL Research Chair,
University of Manchester

Vesa Lakaniemi
Mayor of Eurajoki, Finland

Professor Penny Harvey
Professor of Social Anthropology,
University of Manchester

Professor Cherry Tweed
Chief Scientist for Geological
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Justin Mullins
Consultant editor,
New Scientist and debate chair

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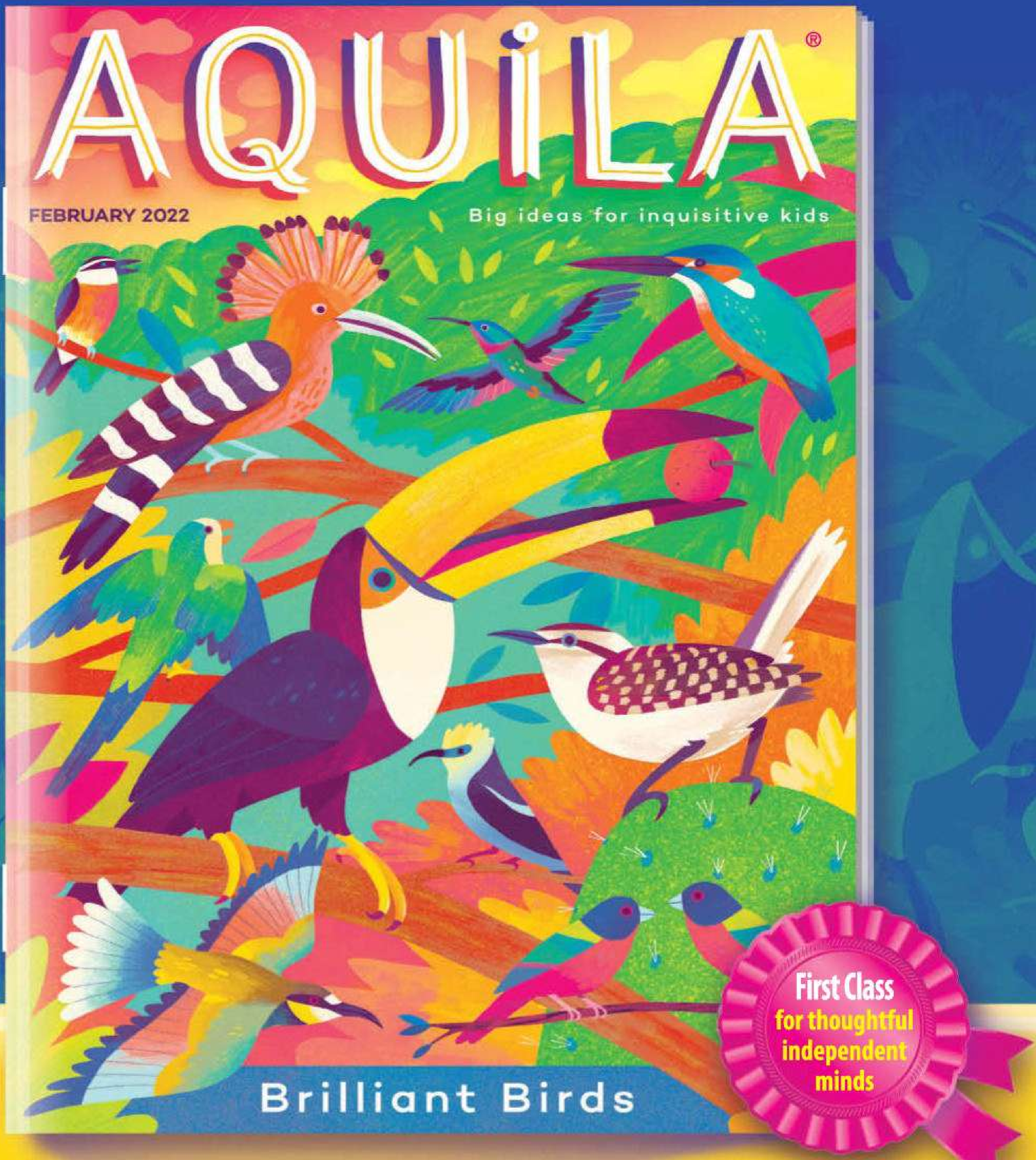
A Vibrant Children's Magazine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Geology rocks

The discipline needs to reinvent itself – and be accorded the respect it deserves

"We learn geology the morning after the earthquake," the 19th-century essayist Ralph Waldo Emerson once wrote. The quote has a pithy resonance as we grapple with the fallout of our inaction on so many fronts, from pandemic prevention to climate change, pollution and biodiversity loss.

Applied to geology itself, it is a case of "if only". These days, hardly anyone learns the subject. In the UK, just over 1000 pupils a year gain an A level in geology, down from almost 4000 four decades ago.

There are many reasons for that squeeze, not least the narrowing of the school curriculum to subjects deemed more "relevant". That perhaps can be traced back to geology's core image problem: it is seen as just a load of dusty old rocks.

A glance at a computer or smartphone – their components cocktails of chemical elements, from silicon in the processor to lithium in the battery, derived from dusty old rocks – should be enough to convince that this is no sustainable objection.

But it speaks to another part of geology's modern image problem: its long history in service of the mining and fossil-fuel industries. Our rapacious consumption of Earth's mineral resources, enabled by geologists' nous, is why we are now debating the definition of a new geological epoch, the Anthropocene.

> "It is time for geology to embrace a new future focused on sustainability"

Geology is, and should be, about so much more. As Christopher Jackson points out (see page 43), it is a window on past climate change and so the best tool we have for understanding our future. And its potential in creating a more sustainable world is huge, be it in learning more about soils to allow farmers to get the most out of their land, in tracing how contaminants affect the provision of safe water supplies or, of course, in helping us to predict and mitigate the effects of earthquakes and other natural disasters that disproportionately hit the world's poorest.

It is time for geology to embrace a new future focused on sustainability and, in turn, be accorded the respect it deserves as a discipline crucial to our understanding of the world and our relationship to it. That way, metaphorically at least, learning geology can become a way to help stop the earthquakes before they happen. ▮

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ROYAL BOTANIC GARDENS, KEW

Climate change

Spring comes early

Warmer temperatures in the UK due to climate change are triggering spring flowers to bloom sooner, reports **Clare Wilson**

SEEN any unseasonably early daffodils showing their faces yet? UK spring flowers are opening nearly a month earlier than they did before the mid-1980s, due to climate change.

That is the conclusion of a study of nearly 420,000 observations of the first flowering date of 406 plants from a UK citizen science project called Nature's Calendar. It has records dating back to 1753 from gardeners and naturalists, as well as bodies such as the UK's Royal Meteorological Society.

Ulf Büntgen at the University of Cambridge and his team found that plants were opening their flowers 26 days earlier on average in the years after 1986 than they did before. They picked that year as it was the midpoint in the data set – where they had about the same number of observations before and after – because there were many more recent records than earlier ones (*Proceedings of the Royal Society B*, DOI: 10.1098/rspb.2021.2456).

The analysis included records of all plants, whatever time of year they flower, but most of them (like the daffodils pictured above) bloom in spring. "It is likely that the influence of climate change will be greater for spring-flowering plants, where the usual onset of warmer temperatures that would trigger flowering starts earlier," says a spokesperson for the UK's Royal Horticultural Society.

There was a bigger advance in the dates of the first blooms for smaller plants, with those less than 20 centimetres high flowering an average of 32 days earlier in the years after 1986 than they had historically.

In any year, flower opening times were closely correlated with the average temperature of the months from January to April. "If it's warmer, it's an earlier onset. If it's cooler, it's a later one," says Büntgen. The average maximum temperature across those four months rose by 1.1°C, comparing the period from 1950 to 1986 with the years after 1986.

The shift could hurt insects, birds and other wildlife that has evolved to sync with the flowering of certain plants, says Büntgen. ▮

Physics

Lightning records set in the Americas

TWO record-breaking lightning flashes occurred in 2020, the World Meteorological Organization has confirmed.

One of the flashes occurred in the southern US in April of that year and had a length of about 768 kilometres, or the distance from London to Hamburg in Germany. This is 60 kilometres longer than the previous record set in Brazil in 2018.

The second flash was measured in June 2020. It straddled the Uruguay-Argentina border, and lasted for 17 seconds, longer than any other flash ever detected (*Bulletin of the American Meteorological Society*, doi.org/hfhh).

The flash that spanned the southern US would have been difficult to measure with conventional ground-based equipment, so meteorologists turned to lightning mappers on geostationary satellites, which have a far wider field of view.

"We have had this type of lightning-detection and mapping equipment in orbit only for a handful of years, and through it, we are learning much more," says co-author Randall Cerveny at Arizona State University.

With both flashes occurring in 2020, it might seem to indicate that lightning is becoming more extreme, but it could simply be that improved imaging capabilities allowed both records to be broken so recently. Alex Wilkins ▮

Animal behaviour

Giant pandas snub their cubs

When cubs are born via artificial insemination, panda mothers are more likely to reject them

Sophie Freeman

GIANT pandas that become pregnant through artificial insemination are more likely to reject their newborn cubs than those that conceive by mating naturally. This finding could help conservationists further increase the number of giant pandas, which remain vulnerable.

As newborns, giant pandas (*Ailuropoda melanoleuca*) are helpless. They require near-constant body contact to keep a steady temperature, don't open their eyes for six to eight weeks and need to be licked to stimulate urination and defecation.

”A newborn panda cub is completely dependent on the mother, and the mother won't even feed or drink in the first few weeks after birth," says Ming Fei Li at PDXWildlife, a conservation charity in Oregon.

Li and her colleagues examined mating statistics recorded between 1996 and 2018 at the Wolong Panda Center and the Bifengxia Panda Base, both in Sichuan province, China. These included observations on 202 cubs produced by 57 females, with 63 cubs born after artificial insemination and 139 born following natural mating.

The pandas that gave birth after artificial insemination were 37.9 per cent more likely to reject a cub than females that mated naturally (*Applied Animal Behaviour Science*, doi.org/hfdk). When a panda rejects a cub, she may ignore it, deny it body contact or refuse to nurse it.

A female giant panda at the Bifengxia Panda Base in China

IMAGINECHINA LIMITED/ALAMY

Without any courtship, the mother panda can't inspect the father of her children – sniffing him, listening to him, observing how he competes with other males – so cannot be assured of his quality, says Li.

While snubbed cubs can be hand-reared by conservation staff, the researchers warn that this can cause trouble further down the line. This is because missing out on the proper social learning interactions during the critical development period can lead to abnormal behaviours in adulthood, which may lower mating success. Li and her colleagues now recommend that conservation programmes prioritise natural mating.

In 2016, giant pandas were reclassified from endangered to vulnerable by the International Union for Conservation of Nature (IUCN), following population growth of nearly 17 per cent over the previous 10 years. At last count, there were 1864 pandas in the wild, according to figures from China's National Forestry and Grassland Administration. There are also 633 pandas in captivity within panda centres in China and zoos around the world.

Nicola Loweth at conservation charity WWF in the UK says the IUCN reclassification was a "step in the right direction", but there are still concerns. "Vulnerable species still have a high risk of extinction," she says. "Several significant threats remain, including habitat loss and fragmentation, snaring and climate change, which is predicted to have significant impacts on the panda's main food source, bamboo." ▮

Technology

Birthday wishes on social media are a security risk

EVERY day, thousands of people are giving away private information about their friends that could compromise their online security – by wishing them happy birthday on social media.

Banks and other organisations often use a customer's date of birth to verify their identity, and security experts therefore advise people not to mention it on social media. It is even protected as personal data under data protection laws in the UK and the European Union.

Dilara Keküllüoğlu at the University of Edinburgh, UK, and her colleagues found more than 18 million Twitter posts that mentioned "happy birthday" in a 45-day period. Of those, 2.8 million directly mentioned a user, so they could be used to ascertain an individual's birthday. More than 66,000 of these tweets also gave away the age of the user, and therefore their full date of birth.

Only around 2 per cent of the Twitter users mentioned in those posts shared their birth years on their profiles, so the team warns that well-wishers are exposing this information for people who haven't proactively shared it themselves (arxiv.org/abs/2201.10655).

Keküllüoğlu says that around 0.85 per cent of tweets in English contain the term "birthday".

"The information you leak and your networks leak, it's one point in the data chain that could get malicious people closer to your account," she says.

"It's one point in the data chain that could get malicious people closer to your account"

But she doesn't think the solution is for us to stop wishing each other happy birthday online. "I wouldn't want that," says Keküllüoğlu. "I think this is something that brings joy to people."

"Date of birth was a good authentication because everyone had one, and it wasn't that guessable if you're not close to that person," she says. "But now, with the introduction of social media, it's no good. If any companies or organisations are using it, they need to move away from it." ▮

Matthew Sparkes

Wildlife

One-third of birds tested in Australia have chlamydia

Alice Klein

A LARGE number of birds treated at an Australian animal hospital are carrying chlamydia, including some novel strains of it. The discovery raises concerns about spillover to people and other animals.

Human chlamydia is caused by infection with bacteria called *Chlamydia trachomatis*. Birds can be infected with a similar strain called *Chlamydia psittaci* that causes flu-like illness and can spread to people.

***C. psittaci* has been detected in more than 460 bird species globally, but little is known about the prevalence of chlamydia in Australian birds.**

To investigate, Martina Jelocnik at the University of the Sunshine Coast in Queensland, Australia, and her colleagues tested 564 birds belonging to 107 species that were admitted to a wildlife hospital in Beerwah, Queensland.

Most of the birds were there because they had been hit by cars or attacked by cats or dogs.

In total, 29 per cent of the birds, including kookaburras, cockatoos and lorikeets, tested positive to chlamydia. Some were infected with *C. psittaci* and some with *Chlamydia pecorum*, a strain that typically affects koalas. Three strains not previously seen in Australia – *Chlamydia abortus*, *Chlamydia ibidis* and *Chlamydia pneumoniae* – were also detected, as were three strains that are new to science (*Transboundary and Emerging Diseases*, doi.org/hfdb).

There are already some reports of *C. psittaci* spreading from Australian birds into people. In one case, 16 people in the town of Bright, Victoria, contracted the bacteria through exposure to bird droppings while gardening, and one died.

At this stage, the health consequences of the new findings are unclear, says Jelocnik. "We're really just scratching the surface."

Health

Gene variant in centenarians may help keep ageing at bay

Michael Le Page

SOME people who have lived to 100 years or more have a rare gene variant that appears to slow down the fundamental processes that cause ageing. The team behind the research says the findings could boost efforts to develop anti-ageing drugs.

Numerous animal studies have shown that the activity of a protein called SIRT6 is strongly linked with maximum lifespan. Vera Gorbunova at the University of Rochester in New York and her team set out to find variants in the gene for SIRT6 that extend human lifespan.

They compared the gene sequences in 500 Ashkenazi Jewish centenarians with another 500 Ashkenazi Jews whose families aren't especially long-lived. They found that 1 per cent of the centenarians had a variant they named *centSIRT6*, compared with 0.5 per cent of the comparison group.

While the result of this initial analysis wasn't statistically significant, in a large database of 150,000 people from diverse ethnic backgrounds, the team also found that longer-lived people were more likely to have the *centSIRT6* gene variant (bioRxiv, doi.org/hfdj).

In a series of laboratory experiments in human cells, the researchers found that the protein produced by this variant has a number of effects expected to slow ageing. One is its superior ability to prevent the build-up of genetic mutations by increasing DNA repair.

Ageing may also be caused partly by a gradual loss of control over what DNA does, and one of the ways DNA activity is controlled is by the way it is packaged. When we are young, the DNA in our cells is packaged very neatly, but as we get older it starts to get messier, says Gorbunova.

"This packaging really deteriorates and becomes disorganised," she says. "It's like if you fold your laundry in a drawer, it's very neat, but then as you keep going in and out of the drawer it gets messy." The centSIRT6 protein is better at keeping DNA tidy, Gorbunova says. "It keeps this packaging together more efficiently."

Another way that this version of the protein could extend lifespan is by suppressing the activity of parasitic sections of DNA called transposons that copy and paste themselves all over the genome. As we get older, suppression of this gradually fails.

This can lead to harmful mutations building up in cells as transposons paste themselves into key sites. What's more, high transposon activity can trigger an inflammatory response by making cells think they are being attacked by viruses – and long-term inflammation is linked to many age-related diseases. The centSIRT6 version of the protein is better than the non-variant form at suppressing transposons.

Anti-ageing drugs could make living to 100 more common

KAJAKIKI/GETTY IMAGES

"I think with all this evidence together, it is very likely that this variant contributes to longer lifespan," says Gorbunova.

"I agree," says Zhengdong Zhang at the Albert Einstein College of Medicine in New York, whose own team has also been looking for rare gene variants associated with longevity in centenarians. "This assessment is supported by their strong experimental functional studies."

1%

of centenarians in the study group had the *centSIRT6* variant

The non-variant SIRT6 protein also exerts these effects to a lesser degree by catalysing two chemical reactions. It removes acetyl groups from some proteins and adds ribose groups to others, which affects the activity of these proteins.

The centSIRT6 variant is less efficient at removing acetyl, but better at adding ribose, Gorbunova's team found. That is important because efforts to develop drugs that boost SIRT6 activity have focused on boosting the acetyl activity, whereas ribose activity now appears to be the key. If they can be created, such drugs might even be able to reverse ageing to some extent, says Gorbunova. "We see some evidence that SIRT6 can rejuvenate."

Other human gene variants have been linked to longer lifespans, but they alter the risk of age-related conditions such as heart disease, whereas this is the first one to address underlying mechanisms of ageing, she says.

Astrophysics

We could save Earth from a planet-killer comet (if leaders listen to scientists)

Jonathan O'Callaghan

EARTH could escape the threat of a devastating asteroid or comet strike with just a short window to act, according to new research.

Netflix's recent science-fiction blockbuster *Don't Look Up* depicts a scenario in which astronomers discover a 10-kilometre-wide comet set to collide with Earth in six months. The film charts their efforts to warn the world of impending doom and convince politicians to take the necessary action to avert catastrophe.

Although the story is intended as an allegory for climate change, Philip Lubin and Alexander Cohen at the University of California, Santa Barbara, wondered if such a scenario would be survivable in the real world. "It looks possible," says Lubin. "It looks like you could do it."

The size of the comet in the film is similar to the asteroid that wiped out the dinosaurs 66 million years ago. If we spotted such an object with a few years until the predicted impact, the preferred strategy would be to deflect it away from an earthbound trajectory.

However, with just six months to act, Lubin and Cohen found that we would instead have to use nuclear devices to "disassemble" the object. They suggest this would be possible with less than 10 per cent of the world's current nuclear arsenal.

The nuclear devices would need to be fitted on 1000 javelin-shaped penetrators, which could be launched on one of two super-rockets that are currently in development: NASA's Space Launch System or SpaceX's reusable Starship vehicle, both of which are expected to launch on their first test flights to space in the coming months.

Astronomers struggle to capture attention in *Don't Look Up*

NIKO TAVERNISE/NETFLIX

The launch would have to occur five months before the asteroid or comet was due to collide with Earth, giving us just a month to prepare. "You have to be ready. You can't wait," says Lubin.

The penetrators would then strike a month before the Earth impact date, exploding in concentric rings from the outer edge of the asteroid or comet towards its centre. That would give us the greatest chance of blasting it into small-enough fragments that would be mostly pushed out of the planet's path (arxiv.org/abs/2201.10663).

"Will any of them hit? Probably," says Lubin. "But if it's a choice between everybody dying and some, you have to make some choices."

Detlef Koschny, acting head of the European Space Agency's planetary defence office, says the idea seems reasonable, but wonders if we would have enough time to act. "Even if there are enough nuclear explosive devices, you'd still need to get them up on a rocket in four weeks," he says. "I don't see how that can happen."

Thankfully, our best surveillance efforts suggest we won't need such a call to arms any time soon. "There's nothing that we are worried about for at least the next 100 years," says Áine O'Brien at the University of Glasgow, UK, "but it's always cool to read these kinds of things." ▮

Climate change

Extreme marine heatwaves are the new normal

THE world's oceans passed a threshold eight years ago as marine heatwaves became the "new normal", with extreme temperatures recorded across more than half of Earth's seas since then.

Marine heatwaves, such as the "blob" of warm water in the Pacific Ocean between 2014 and 2016, can cause algal blooms, coral bleaching and mass die-offs of fish and birds that feed on them.

Kyle Van Houtan at Duke University in Durham, North Carolina, and Kisei Tanaka at the US National Oceanic and Atmospheric Administration have now found that 2014 was the first time that more than half of the global ocean surface recorded temperatures were considered extreme compared with a historical baseline. By 2017, such temperatures covered a high of 60 per cent of the oceans (*PLOS Climate*, DOI: 10.1371/journal.pclm.0000007). The figure was less than a fifth in the early 1900s.

While the oceans as a whole crossed the threshold of 50 per cent only recently, some areas hit it far earlier. The South Atlantic passed the milestone in 1998. "That was a long time ago. I think that's really jarring," says Van Houtan.

The team looked at two sets of global sea surface temperature data from 1870 to 2019, using the first 50 years to establish a historical baseline. The hottest 2 per cent of temperatures were deemed extreme. This was then used as a yardstick to map the prevalence of extremes up to 2019. "They are reinforcing the idea that climate change is already well in progress," says Nick Bond at the University of Washington in Seattle. One thing to bear in mind is that the baseline period was relatively cold, he says.

"This global data set is reinforcing the idea that climate change is already well in progress"

Alex Sen Gupta at the University of New South Wales in Sydney, Australia, says: "We are becoming increasingly aware that it's temperature extremes rather than mean climate that have the most extreme effects on marine organisms." ▮

Adam Vaughan

New Scientist
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Briefing

Another flavour of omicron

The BA.2 variant of the coronavirus is spreading fast, but it shouldn't cause another worldwide wave, says **Michael Le Page**

ANOTHER year, another variant. Even before the omicron wave is over, the rising number of cases caused by a form of the coronavirus known as BA.2 is causing concern.

What is BA.2?

It is basically another flavour of omicron that has been around right from the start. The term omicron is used to describe a whole family of variants that appeared suddenly in November 2021. Most omicron cases have been caused by one of these variants known to scientists as BA.1. Although BA.2 has 32 of the same mutations as BA.1, it also has 28 that are different. The first BA.2 sample was collected in South Africa on 17 November 2021.

Why are we hearing about it now?

In several countries, including the UK, Germany, India and Denmark, the proportion of cases caused by BA.2 is increasing rapidly. In other words, BA.2 is replacing BA.1, which suggests that it is even more transmissible.

Should I be worried about BA.2?

If you are unvaccinated and haven't been infected by omicron, then yes. If you get infected, even if you don't become severely ill, you could start a chain of infections that does result in deaths.

Can I get infected with BA.2 if I have had omicron already?

We don't yet know, but many researchers think that if people have recently been infected by BA.1, they are unlikely to get BA.2, especially if they have also been vaccinated. That isn't to say this won't happen, but the numbers are expected to be low.

TOLGA AKMEN/AFP VIA GETTY IMAGES

A volunteer hands out covid-19 tests in London in January

"Antibodies elicited by BA.1 will still probably react reasonably well against BA.2, certainly much better than delta antibodies," says Jesse Bloom at the Fred Hutchinson Cancer Research Center in Seattle.

What if I have been vaccinated but haven't had omicron?

The existing vaccines are actually even better at protecting against BA.2 than BA.1. According to the UK Health Security Agency, three vaccine doses are 70 per cent effective at preventing symptomatic infections by BA.2 two weeks after the booster, and 63 per cent effective against BA.1. For people with two vaccine doses, the efficacy after 25 weeks is 13 per cent against BA.2 and 9 per cent against BA.1. These are the combined numbers for all vaccines used in the UK.

Will BA.2 cause yet another wave of cases around the world?

Hopefully not, though it might prolong the current omicron waves in many countries. In South Africa, whose omicron wave is pretty much over already, there is no sign of a resurgence despite a high proportion of cases now being BA.2. However, nations that have largely succeeded in preventing the spread of covid-19 so far, such as Japan, might find it even harder to suppress BA.2 than BA.1.

Does all this mean that BA.2 is less dangerous than BA.1?

Probably. The threat a virus poses depends on its inherent severity, how many people it infects and how much immune protection people have. As far as we know, BA.2 is no more likely to cause severe illness than BA.1, yet it may be 50 per cent more transmissible. More transmissible viruses can cause more hospitalisations and deaths by infecting more people, even if they are no more severe. But in many countries, a large proportion of people now have good immunity due to boosters and infections, which should greatly reduce both the number and severity of BA.2 infections. ■

Mathematics

Game theory shows how people crowd on rush hour trains

Alex Wilkins

A MODEL informed by game theory shows how the areas around train doors become crowded at rush hour. It could eventually be used as a tool for designing safer public venues.

When two parties interact, such as countries vying for resources, the situation can be modelled using game theory, which assumes both parties make rational decisions.

Thibault Bonnemain at Northumbria University in Newcastle upon Tyne, UK, and his colleagues used a combination of game theory and the physics of complex systems to work out how crowds might move, based on modelling how an individual reacts to the crowd surrounding them.

They focused on modelling the crowd member's immediate environment, taking into account the other individuals that were within touching distance. But the model also assumed that the crowd member would look beyond this local area and adjust their behaviour in response to potential obstacles.

"A key aspect of this work is anticipation," says Bonnemain.

> "The virtual members of the crowd mimicked real-world behaviour at railway stations"

When Bonnemain and his team ran simulations based on equations they developed, they noticed the virtual members of their crowds mimicked real-world behaviour. For instance, in a virtual railway station, crowds formed around train doors, with the density of people highest as the doors closed (arxiv.org/abs/2201.08592).

The model is still in development, but Bonnemain says it could eventually have real-world applications – for instance, in designing venues that crowds can enter and exit quickly and easily. ■

New Scientist
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Biology

Whiteflies have acquired dozens of genes from the plants they eat

Jake Buehler

WHITEFLIES appear to have taken the saying "you are what you eat" somewhat literally. New research suggests the tiny, herbivorous insects have incorporated dozens of genes from plants into their own genome.

This volume of genes jumping from plant to animal far exceeds what was previously known in insects, and may lead to new ways to control this major pest of fruit and vegetable crops.

When DNA is passed between separate branches on the tree of life, it is called horizontal gene transfer. It is mainly known to occur between different species of bacteria, or between bacteria and eukaryotic organisms – those with cells containing membrane-bound organelles, like animals, plants and fungi.

In March 2021, researchers reported the first known case of plant-to-animal horizontal gene transfer in silverleaf whiteflies (*Bemisia tabaci*). Sometime in their evolutionary history, the insects acquired a single gene from a plant they ate, which may help them to detoxify chemical defences produced by plants.

NIGEL CATTLIN/ALAMY

A pair of silverleaf whiteflies (*Bemisia tabaci*)

Separately, Florian Maumus and Clément Gilbert, both at the University of Paris-Saclay in France, developed a program to detect virus genes embedded in the genomes of eukaryotes. It works by using databases to identify the species a gene comes from, revealing foreign genetic material mixed in with the host's genes. After seeing the 2021 study on whitefly gene transfer, they wondered if they could use their program to find more plant genes in the whitefly genome.

They found 50 different plant genes that the whiteflies acquired in 24 independent transfer events. Based on what scientists know about the genes most closely related to the transferred versions, many have some role in the plant's response to parasites and disease.

Many of the genes are transcribed into RNA in the whiteflies' cells, which suggests they have an active function, although the researchers haven't tested their function directly (bioRxiv, doi.org/hfdw).

Whiteflies are notorious agricultural pests that feed on hundreds of plant species. Maumus thinks the adopted genes may help the whiteflies adapt to a wide array of hosts.

It isn't yet clear how these genes are taken up by the whiteflies, but viruses may play a role, says Maumus, given whiteflies are important carriers of scores of plant viruses. The genes may also piggyback on other jumping genetic elements called transposons.

"I'm quite amazed by the number of transfer events from plants to these insects," says Nicky Wybouw of Ghent University in Belgium, adding that it is incredible that these genes have moved intact across kingdoms of life.

"The whole [genetic] machinery has to still maintain its function, and its interaction with other proteins also has to match," he says. "That's an additional layer of complexity."

Ted Turlings at the University of Neuchâtel in Switzerland – part of the team that reported the first plant-to-whitefly gene transfer – says the latest findings could lead to new ways of controlling the pests by interfering with the genes that let them cope with plant defences. ▮

Solar system

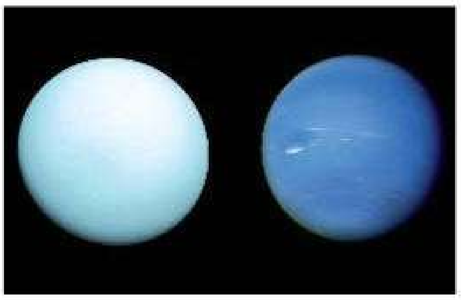
An explanation for the different blues of Uranus and Neptune

URANUS and Neptune are different shades of blue, and we may finally know why.

In visible-light images, Uranus appears a pale blue, while Neptune is a deeper, cobalt hue. Using data from the Hubble Space Telescope and ground-based observatories, as well as information gleaned from the Voyager 2 spacecraft, Patrick Irwin at the University of Oxford and his colleagues have developed detailed models of the atmospheres of both worlds that might explain the colour difference.

The thick, enshrouding skies of these planets are mainly made of hydrogen and helium as well as methane. But hazes comprising other chemicals are thought to be floating at different altitudes too. These are probably created when methane is broken down by the sun's ultraviolet radiation, before reforming as larger hydrocarbons.

In their new models, the scientists identified a haze layer, thought to be present on both worlds, which is roughly twice as thick on Uranus as it is on Neptune. This feature, which the team calls the aerosol-2 layer, would look whitish at visible wavelengths. So the greater thickness of the aerosol-2 haze on Uranus would lighten the planet's appearance – similar to how tracing paper placed over a picture makes its vibrant hues more milky (arxiv.org/abs/2201.04516).



NASA/JPL-CALTECH

Uranus (left) and Neptune, as imaged by NASA's Voyager 2 spacecraft

"This explains why Uranus is a paler blue colour than Neptune," says Irwin.

As for why the two gas giants are blue in the first place, that is down to the methane in their atmospheres, says team member Leigh Fletcher at the University of Leicester, UK. "Methane absorbs red light, leaving blue to be reflected back," he says.

Questions still remain about the nature of darker areas on the planets, says Naomi Rowe-Gurney at NASA's Goddard Space Flight Center in Maryland. "I am sure that the James Webb Space Telescope will help with this." ▮

Will Gater

Zoology

Hibernating ground squirrels recycle urine to survive

Alex Wilkins

GROUND squirrels stay in shape while hibernating because their gut microbes recycle urea, the main compound in urine.

When animals hibernate, they enter a state of suspended animation, reducing their energy use and food intake. But the lack of food can lead to a dearth of nitrogen, an essential building block for establishing and maintaining muscle.

> **"The microbes are important in all this because they have this ability to break down urea"**

Matthew Regan at the University of Montreal, Canada, and his colleagues have now discovered how thirteen-lined ground squirrels (*Ictidomys tridecemlineatus*) overcome the problem. Their gut microbiomes harvest nitrogen from urea, which is typically a waste product.

Regan and his team examined several groups of ground squirrels at various stages of their hibernation cycles, but gave half of the animals microbiome-depleting antibiotics. In the untreated squirrels, the researchers tracked nitrogen compounds like ammonia and glutamine all the way from the squirrels' stomachs to muscles.

For the depleted squirrels, these compounds weren't found in significant numbers in their muscles (*Science*, doi.org/hd34).

"The microbes are important in all this because they have this ability to break urea down into its component parts," says Regan.

The urea-eating bacteria also benefit from this process, which could explain how the mutually beneficial arrangement came about. "It's a symbiosis that allows both of them to effectively emerge from hibernation in good shape," he says. ▮

Briefing

Google moves to drop cookies

Privacy concerns have pushed the web giant to change how it tracks us online, explains **Matthew Sparkes**

GOOGLE has been planning for years to scrap cookies, the tiny files stored on our computers as we browse the internet that allow advertisers to track us and tailor what they show us. Last week, it announced it is ditching its planned replacement, called Federated Learning of Cohorts (FLoC), in favour of a new tool called Topics. Here's what the change means for you and your online privacy.

Why do we need any kind of tracking at all?

Tracking is less about providing a service for users and more about advertising and profit. Advertisers pay to place their products and services in front of certain people they feel may be potential customers. Tracking, via large data-collecting companies like Google or Meta, allows them to do that.

But many people are growing more and more uncomfortable with the extent to which firms track, analyse and market to them. And governments around the world are increasingly legislating to rein in these tech giants. Companies like Google may be partly reacting to changing customer sentiment with these new tools, but the truth is that they are also being forced to act.

What's the new plan?

The new tool, Topics, does the same thing FLoC was supposed to – keep our identity and movements hidden from advertisers – but in a slightly different way. Google's Chrome browser will include code that monitors the sites we visit and learns about our interests. It will store this information locally for only three weeks at a time, and categorise us all with tags from a list of 300 interests such as "fitness" or "fashion".

When visiting a website, your browser will allow advertisers access to three of these topics, chosen at random, so they can decide which adverts to show you. Crucially, those three topics are all that the website and the advertiser will be allowed to know about you – they won't get information about gender or race, for instance.

But concerns remain in some quarters. "The Topics API only touches the smallest, most minor privacy issues in FLoC, while leaving its core intact," wrote Peter Snyder in an article on the website of the privacy-focused browser Brave.

What will it mean for web users and advertisers?

Topics will only gather information on Chrome users, although many people who prefer other browsers are likely to use Google's web search, email, calendar or myriad other services, so the firm can still gather information from those. But there are other options for the privacy-conscious, such as Apple's Private Relay, which allows you to browse anonymously and keep data out of advertisers' hands.

The changes are likely to make life harder for advertisers, which have grown used to being able to access a wealth of data and closely target adverts. It is in Google's interests to avoid too great an impact on advertisers, as far as rules like the EU's General Data Protection Regulation (GDPR) allow it to – after all, Google makes its money from advertising.

What happens next?

Google says it will officially end support for third-party cookies in the middle of 2023, although this date has been delayed before. At that point, other advertisers will no longer be able to place cookies and track Chrome users. Google says that Chrome will allow users to see their assigned topics, remove any they wish to or even disable the feature completely.

Advertisers, technology giants and regulators will be closely monitoring developments. ▮

Google's logo at the entrance to its UK offices in London

OLLY CURTIS/FUTURE VIA GETTY IMAGES

Psychology

We 'click' better in conversations with quick responses

Richard Sima

THE connection we feel to others when we have a good conversation isn't based solely on the content of the chat. Research shows that the faster people respond to one another, the more they feel in sync.

Conversations involve turn-taking, with back-and-forth replies happening within a mere quarter of a second on average.

This response speed is key for feeling social connection, according to experiments by Emma Templeton at Dartmouth College in New Hampshire and her colleagues. The faster the response, the more people felt as if they both liked and "clicked" with their conversation partner, be they strangers or close friends.

In one experiment, Templeton's team paired up 66 English-speaking strangers for 10 conversations, each 10 minutes long, with different people, and asked them to rate how much they enjoyed the experience. Conversations with shorter gaps and faster response times, including interruptions, were the ones people said they enjoyed more and felt more connection in (*PNAS*, doi.org/gn7d8h).

The team also asked people to listen in on conversations they didn't participate in. They perceived exchanges with shorter response times as being more connected. When Templeton's team played audio clips of conversation but artificially manipulated the response times, people listening in on these chats reported that the participants seemed more connected when the response times had been shortened to one-fifth of their original length rather than being untouched or doubled. ∎

250

Milliseconds between responses in a conversation, on average

Astronomy

Gravitational wave echoes could reveal dark matter

Leah Crane

GIROSCIENCE/ALAMY

An illustration of gravitational waves spreading in space

THE entire universe is suffused with gravitational waves, ripples in space-time caused by the motion of massive objects. As they flow across things like stars and planets, parts of these waves should slow down and travel just behind the original ripple in a kind of echo that could let us examine celestial objects we can't see – maybe even dark matter.

Only the most massive objects in the universe create measurable gravitational waves. Most of the ones that have been detected so far have come from pairs of black holes coalescing. As the black holes move, they create ripples that travel outwards at approximately the speed of light.

But the gravity of other cosmic objects, even those less massive than a black hole, can slow down the ripples as they pass by. The parts of the wave that are slowed down would then arrive at our detectors later, in what researchers call a gravitational glint.

Glenn Starkman and Craig Copi at Case Western Reserve University in Ohio calculated how this phenomenon would affect the signals of the gravitational waves that we detect on Earth.

They found that gravitational glints created by relatively massive objects, such as stars, could theoretically be spotted with the detectors we have now (arxiv.org/abs/2201.03684).

"All gravitational waves should have these glints, it is just a question of how strong they are"

"We can use gravitational waves to explore the universe – to explore the contents of the universe, not just the sources of gravitational waves," says Starkman.

Because gravitational waves travel directly through everything, they could even provide us with an opportunity to peer inside neutron stars or other exotic cosmic objects. If dark matter – a mysterious substance thought to make up around 80 per cent of all matter – exists in the form of massive objects or dense clusters of particles, this method could even help us probe its nature.

"These effects are particularly remarkable because they provide a way to use gravitational waves to possibly learn about objects that do not necessarily emit gravitational waves at all," says Lucy McNeill at Kyoto University in Japan. "This includes things that don't interact with light, such as dark matter candidates." All we need to do is observe a gravitational wave that came from behind the object in question.

"All gravitational waves should have these glints," says Starkman. "It's just a question of how strong the signals are."

He and Copi calculated that the glints should typically be about 10 per cent as strong as the gravitational waves that produce them. With the sensitivities of current detectors, that means we should be able to spot about one every three years.

"If this is true, it would be quite exciting," says Paul Lasky at Monash University in Australia. "Having said that, I foresee a lot of technical problems in actually being able to confidently extract this signal from the data for that one event." He says we may need "considerably more sensitive" gravitational wave detectors.

The researchers are now working with gravitational wave observers to figure out how we might be able to identify gravitational glints and what we could learn about their sources. "Stars may fade and dark matter may never glow, but they can't hide from gravity," says Starkman. ∎

PALLADIUM

CHALLENGE CONTEST

Nornickel, the world's largest producer of palladium and high-grade nickel and a major producer of platinum and copper, announces the start of the Palladium Challenge, a contest with a USD 350,000 prize fund organised in partnership with the International Precious Metals Institute (IPMI).

The Palladium Challenge is an initiative intended to inspire individuals, businesses and academic institutions to invent and design a sustainable use-case that features and increases the demand for palladium. The metal is known for its catalytic capabilities and unique physical properties, and while it is widely used in the automotive industry as an essential component of catalytic conversion, the Palladium Challenge seeks to broaden its applications and spark innovation.

The Palladium Challenge will be judged by an independent panel of global experts who will review all submissions.

The **top three projects** will receive global recognition and **will be awarded monetary prizes on September 16, 2022** at the IPMI Annual Platinum Dinner in New York City.

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Palaeoanthropology

Fossil skull may be Denisovan

Denisovan humans lived in east Asia during the Stone Age, and ancient bone fragments might give us our first glimpse of one of their skulls, finds **Michael Marshall**

AN ANCIENT human that lived in what is now China at least 160,000 years ago had an unusually large brain for the time – comparable to the brain size of people alive today. The find is more evidence that hominin evolution went in many different directions, rather than taking a straight line from small brains to large ones.

It is also possible that the skull belonged to a mysterious kind of hominin called a Denisovan, which is thought to have lived in east Asia at the time. Very few Denisovan bones are known, and so far no skull fragments have been found. There is evidence that the Denisovans were particularly big-bodied, in which case large brains would be expected.

The newly described bones come from Xujiayao, an archaeological site in northern China that was first excavated in the 1970s. Down the years, the site has yielded 21 fragments of hominin skeletons, ranging from teeth and bits of jawbone to pieces of skull. “These fragments represent at least 10 individuals,” says Xiu-Jie Wu at the Chinese Academy of Sciences in Beijing.

Wu and his colleagues have now found that three of the skull fragments fit together, suggesting they all belonged to the same individual. They call this hominin Xujiayao 6, or XJY 6. The sediment in which it was found is between 160,000 and 200,000 years old.

The researchers have calculated the volume of the hominin’s brain from the size and shape of the skull fragments. Their estimate is that it was between 1555 and 1781 cubic centimetres, with a figure nearer to 1700 cubic centimetres most likely (*Journal of Human Evolution*, doi.org/hd3t).

That is unusually large for the time, says Wu. Back then, hominin brains had an average volume of 1200 cubic centimetres. Instead, Xujiayao 6 is on a par with later members of our species (*Homo sapiens*) and with Neanderthals, some of whose brains were 1700 cubic centimetres or a little larger.

The analysis looks like it was carefully done, says Dean Falk at Florida State University in Tallahassee. “We can probably believe it’s a reasonable estimate of the cranial capacity.”

There has been an overall trend of increasing brain size among hominins – but that trend hides a lot of complexity.

For Wu, Xujiayao 6 is “the earliest evidence of a brain size that falls in the upper range of Neanderthals and modern *Homo sapiens*”. But while Xujiayao 6 may have belonged to a big-brained population, other hominins around at the same time had very small brains. The “hobbits” (*Homo floresiensis*) who lived on Flores in Indonesia until about 50,000 years ago had brains measuring just 400 cubic centimetres, while in southern Africa 350,000 years ago, *Homo naledi* had brains measuring 560 cubic centimetres. Even early members of our own species didn’t have brains as large as living people: *Homo sapiens* skulls from a 315,000-year-old site in Morocco had brains measuring 1300 to 1400 cubic centimetres.

> “The skull is the earliest evidence of a brain size that falls in the upper range of living humans”

However, Xujiayao 6’s big brain tells us little about its mind, says Lynne Schepartz at the University of the Witwatersrand in Johannesburg, South Africa. “We are long past the days when brain size was the ‘cerebral Rubicon’ used to assign human status,” she says. Big brains aren’t necessarily linked to intelligence. “Human populations in colder environments have larger brains,” she says, but that is because of “thermal packaging” that keeps the neurons warmer and thus able to function.

What kind of hominin was Xujiayao 6? For Wu, it is probably something new. “Some new type of *Homo*, or new species, existed in the late Pleistocene,” he says.

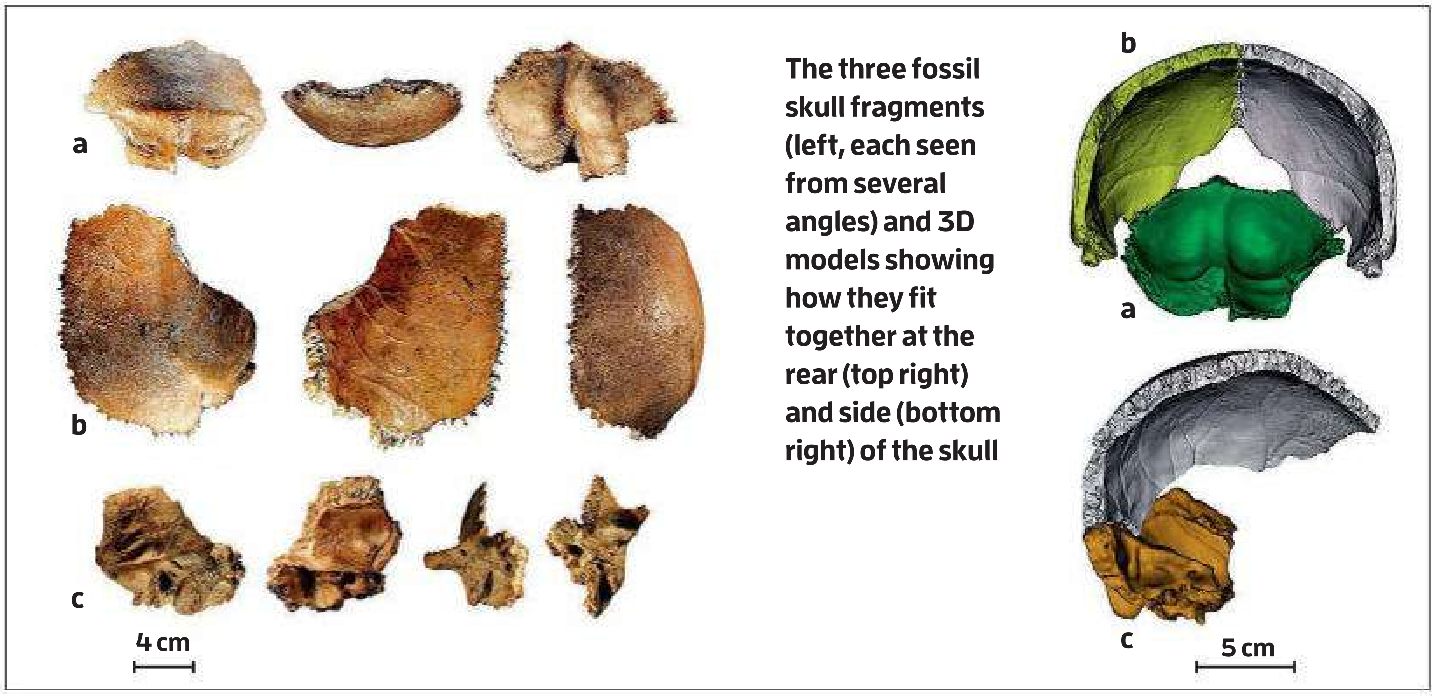
With only three fragments of skull to go on, a firm identification is impossible, says Falk. “I’m wary to point to a specimen and try to identify the species.”

Bence Viola at the University of Toronto in Canada says there is a simpler alternative to naming a new species. The Denisovans existed in east Asia at this time. They were first identified using DNA from fragmentary remains in Denisova cave in Russia, and have since been found on the Tibetan plateau. The few known bones look unusually large, and the teeth from Xujiayao have been speculated to be Denisovan because they are also big.

“Honestly, this is probably the same stuff,” says Viola. “Until we have DNA, we’ll never 100 per cent know, but it’s obviously a good fit.”

It isn’t the first time a potential Denisovan has shown up. Last year, a partial skull from Harbin in China was described. Some of the researchers involved argued it belonged to a new species, which they called *Homo longi*. But others think it was probably a Denisovan.

Wu is open to the idea that Xujiayao 6 is a Denisovan. But because we don’t yet have confirmation of what Denisovan skulls look like, “this needs further evidence to prove it”. ▮



The three fossil skull fragments (left, each seen from several angles) and 3D models showing how they fit together at the rear (top right) and side (bottom right) of the skull

XIU-JIE WU ET AL.

Wild Wild Life newsletter
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Animals

Some bee colonies have to kill thousands of wannabe queens

Christa Lesté-Lasserre

SOME stingless bees seem to be able to choose whether to become a worker or a queen – but thousands of contenders for the throne are executed in each hive.

About one-fifth of all *Melipona beecheii* stingless bee larvae start to develop as queens, but the colony accepts only one. The rest are attacked by strong-jawed workers within seconds of emerging from their cells.

Biologists suspected that colonies of this species overproduce queens as an evolutionary strategy to take over other hives. But it now seems that it is simply a result of the "selfishness" of individual larvae, to the detriment of the whole colony, says Ricardo Caliari Oliveira at KU Leuven in Belgium.

"People think there is a design in evolution, but in this case the bees are just making the best of a bad situation," he says. "The colony is spending a lot of resources to produce new individuals, and then all they can do afterwards is waste those resources and kill the queens."

In most bee colonies, including those of around 500 species of stingless bees, workers select one larva to become the sole queen by raising it in a larger cell and feeding it a special diet. But larvae of the *Melipona* genus all live in cells of the same size and receive the same food.

In 2010, researchers suggested that *M. beecheii* workers were feeding a chemical called geraniol to the future queens. Caliari Oliveira and his colleagues wondered if the bees chose so many queens in order to spread the colony's DNA into other hives through parasitism.

A *Melipona beecheii* worker bee attacking a newly emerged queen

JORGE RAMIREZ PECH

To investigate further, they took genetic samples of queens and workers from 25 free-ranging *M. beecheii* colonies at or near the Autonomous University of Yucatan in Mexico.

In the lab, they also gave higher doses of geraniol or saline to more than 600 larvae. To their surprise, they discovered that extra geraniol didn't affect larval development, so workers weren't controlling queen production after all. Genetic sequencing revealed that the DNA of each hive remained 100 per cent consistent, showing no evidence of parasitism (*Biology Letters*, doi.org/hd2w).

In *M. beecheii* colonies, virgin queens run around the hive in desperate and usually unsuccessful efforts to evade the worker guards, says Caliari Oliveira. Survivors might try to enter a different hive, only to be killed by that colony's guards.

"This is a very good example of the tragedy of the commons," says Caliari Oliveira, when a chase for personal gain harms society.

The study "settles a bit of a controversy" about *Melipona* bees, says Christoph Grueter at the University of Bristol, UK. But it doesn't offer a new explanation for how the larvae "decide" to become queens. "For me, this is still one of the biggest puzzles in biology," he says. "Is it a gene? A particular combination of genes? An interaction between certain nutritional factors and genetic elements? We just don't know." ▮

Astronomy

First intergalactic supernova remnant may have been seen

THE remains of a star that exploded in intergalactic space, outside the realms of any galaxy, may have been spotted for the first time.

Most exploding stars, or supernovae, reside in galaxies, but some have been seen outside galaxies. These are known as intergalactic supernovae, and may be stars that were thrown from host galaxies. We have seen intergalactic supernovae, but never in our galactic neighbourhood, so we haven't observed the remnant of one as it expands into the sparse gas between galaxies.

Miroslav Filipović at Western Sydney University in Australia and his colleagues think they have now seen one between our Milky Way and a neighbouring galaxy called the Large Magellanic Cloud (LMC).

The object, called J0624–6948, appears ring-like in shape, which is consistent with a supernova remnant, and is estimated to be about 150 light years across. It was initially detected in 2019 using the Australian Square Kilometre Array Pathfinder (arxiv.org/abs/2201.10026).

The team thinks the star that caused the supernova would have exited the LMC about 40 million years ago, before exploding between 2000 and 7000 years ago. "The circularity of this object is extraordinary," which points to it being a supernova expanding unhindered into sparse intergalactic space, says Filipović.

"If it does not expand over the next 10 to 15 years, then I have no idea what this object could be"

Tom Oosterloo at the Netherlands Institute for Radio Astronomy isn't completely convinced that this supernova is intergalactic. The team estimates the object is 10,000 light years outside the LMC, but the exact distance is unknown. "It could be associated with the LMC," he says.

Further observations could help resolve the matter, and confirm its supernova status. "If we detect a small expansion, that means we're on the money," says Filipović. "If it does not expand over the next 10 to 15 years, then I have no idea what this could be." ▮

Jonathan O'Callaghan

AN IMPORTANT MESSAGE FROM PROFESSOR NICK LEMOINE CBE MD PHD FMEDSCI, CHAIR OF THE MEDICAL RESEARCH FOUNDATION

Gifts in Wills could be the key to protecting the future of human health

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"The funding I received through the Medical Research Foundation will be transformative for my research." Dr Myrsini Kaforou

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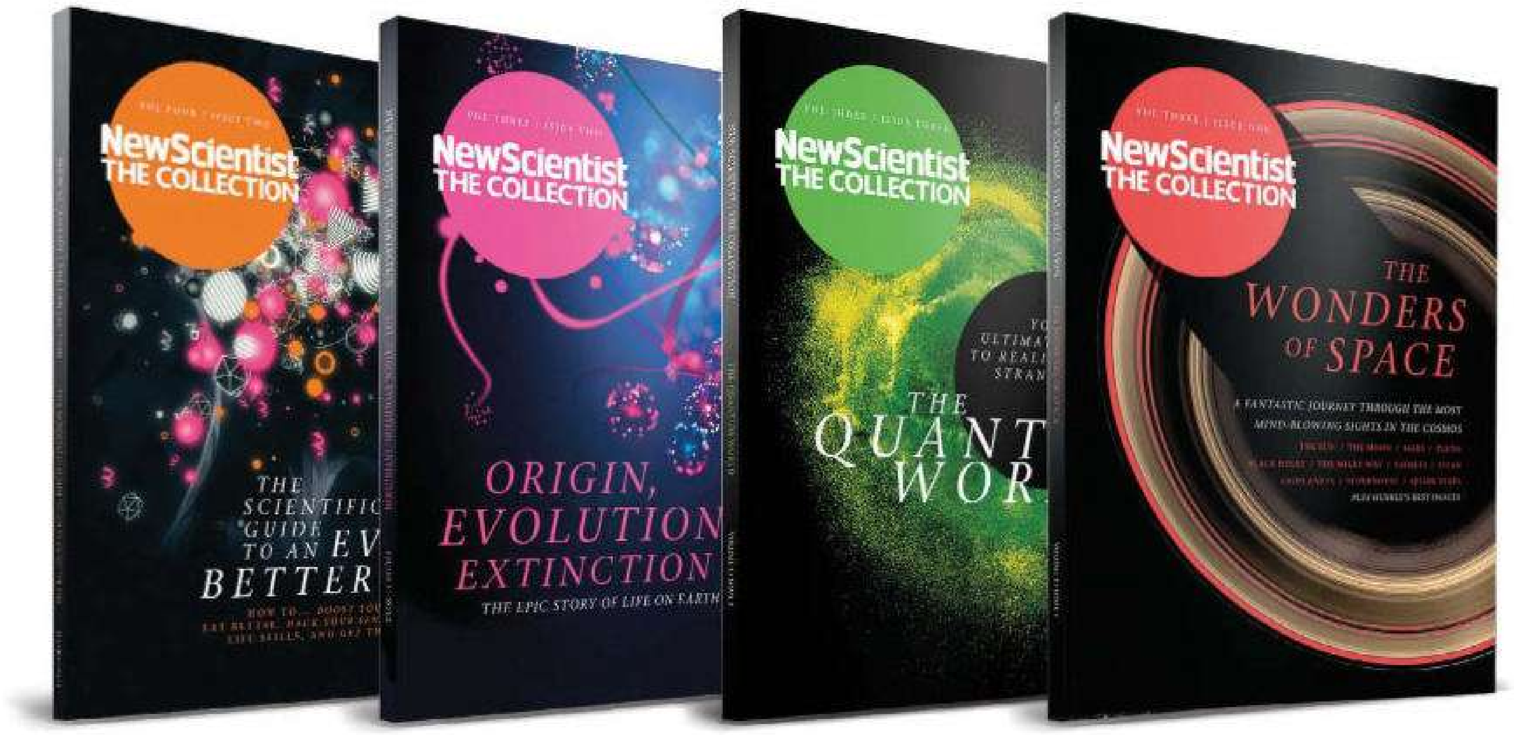
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Field notes Environment

How to clean up a river

A partnership between farmers, the water industry and local volunteers may provide the answers to a river pollution crisis in England, finds **Adam Vaughan** in Oxfordshire

"IT'S depressing. It's something we should be able to put right," says Mark Purvis, standing next to a brook feeding the Evenlode, a river in the Cotswolds area of southern England that has been plagued with water pollution in recent years. "We've seen declines in numbers of fish, insects and weed growth in the river. And terrible turbidity [cloudiness] in summer," he says.

The Evenlode's problems aren't unique. England's rivers are "a mess", a report by MPs on the Environmental Audit Committee (EAC) concluded last month, due to a lack of funding and monitoring and what was called "a 'chemical cocktail' of sewage, agricultural waste, and plastic". But a special partnership between local people, the water industry, farmers and others means that the Evenlode could hold the answers to how the nation can clean up its rivers.

The pressure for action is growing: on 23 January, around 500 people protested in Oxford against sewage discharges in nearby rivers, in the wake of concerning footage of effluent flowing from a sewage works in a catchment area adjacent to the Evenlode.

Follow the brook upstream from where Purvis, a local resident, is standing and you get to the Milton-under-Wychwood sewage treatment works, one of 19 such facilities in the river's catchment area that have sometimes struggled to keep up with a growing population. There were 96 occasions last year when untreated sewage spilled into the brook as the works ran out of holding capacity, for a total of 1406 hours.

"It's a very high-spilling site," says Andrew Scott at Thames Water as he overlooks a concrete storm tank at the works. The facility is small, old and vulnerable not just to rainfall, but also to water "infiltrating" through the ground.

Charlotte Henderson (above) and an aerial view of the river (left)

Part of Thames Water's answer to this problem is a £1.7 million upgrade due to take place by 2025, which should increase the volume of water the site can process per second by a third, meaning it doesn't need to spill.

The Evenlode's problem pollutant is phosphorus, rather than nitrogen as in some other rivers. Around two-thirds of the phosphorus comes from sewage treatment works, including Milton-under-Wychwood. Another 28 per cent comes from agriculture and land use, such as cow dung and phosphate-laden soil that has washed off farms.

The Milton-under-Wychwood sewage treatment works

DAVID STOCK

Over in wheat fields at the nearby Bruern Estate, farm manager Matt Childs points to his efforts to stop that phosphorus reaching the Evenlode. Fences have been erected to keep cows and their dung away from streams where land is prone to flooding. Most of the phosphorus is locked in the soil, so a big focus is keeping that from reaching waterways around the 5-square-kilometre farm.

The corners of some fields have been designated as buffer areas for flooding, while embankments have been raised around fields to keep water in and the soil is managed to help it retain water, such as by avoiding tilling in some fields. A series of ponds have also been created in one field to filter phosphorus out of the water. The estate's biggest water quality issue turned out to be leaking septic tanks – now replaced – rather than food production.

Water quality can be a low priority for some farmers due to how it is regulated, says Childs. "It's very much, for me, a personal thing to do it properly. But you're aware if you don't, there's not much of a downside."

Back at the brook with Purvis, local volunteers are pursuing another route to cleaner rivers: getting a better handle on what is actually happening. Monitoring of England's rivers is "outdated, underfunded and inadequate", the EAC said in its recent report.

While community partnerships like the one in the Evenlode catchment area have been around in England since 2013, this is a new, enhanced version with serious resourcing: £3 million over five years from Thames Water. That means it can provide serious equipment, such as the £25,000 metal cylinder that Charlotte Henderson at the charity Earthwatch pulls out of the stream. It gauges pH levels, biological oxygen demand and faecal matter – and it will soon broadcast its measurements online in real time. "It's about making the invisible visible to people," says Henderson.

Whether such beefed-up partnerships can be replicated regionally or nationally remains to be seen, but Purvis is hopeful that a cleaner Evenlode is possible. "I'd like to see this river running clear through the summer, with children playing in the river safely, dogs able to swim without getting sick and with wonderful wildlife we should see on all our Cotswold rivers," he says. ▮

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Zoology

Cocktail of chemicals allows frogs to regrow lost limbs

ADULT frogs can regrow a leg if they are treated with a device containing a silk gel infused with five regenerative chemicals. The new limbs can apparently move and sense as well as the original legs.

Although tadpoles and young froglets can regenerate their hindlimbs, adult frogs lack the capacity to do this.

To overcome this, Nirosha Murugan at Algoma University in Ontario, Canada, and her team used a small cylindrical device, called a BioDome. This is made of a silicone outer layer with an inner layer of silk processed and incorporated into a polymer called a hydrogel.

They amputated the right hindleg of 115 frogs (*Xenopus laevis*). The frogs were then placed into one of three groups. Those in the first group wore a BioDome over the wound site that had been loaded with a cocktail of five drugs known to help cells regenerate. Frogs in the second group wore BioDomes without the drug cocktail and the third group received no treatment at all. The frogs that wore a BioDome did so for one day.

After 18 months, frogs that received a BioDome containing the drug cocktail had regrown legs with digit-like structures. Each frog could use its new leg to stand on, swim and push off walls. The other frogs didn't regrow limbs. The new legs carried nerves, blood vessels and bone in patterns similar to those in the original legs (*Science Advances*, doi.org/hd4p).

The researchers are now testing the approach in mammals. Murugan thinks it may have the potential to be tested in humans. **Carissa Wong**

Health

Older adults boosted by vitamin D tablets

TAKING supplements of vitamin D prevents some people developing an autoimmune disease, at least for those aged over 50, in a study providing the first evidence of a causal link between the two.

Previous studies on the effect of vitamin D on autoimmune conditions have looked at those with an autoimmune disease or those who go on to develop one. Other studies have hinted at the supplement's beneficial effects on the immune system, but no studies had proven the link.

To remedy this, Karen Costenbader at the Brigham and Women's Hospital in Boston and her colleagues randomly split nearly 26,000 people in the US who were 50 or over into two groups, giving them either vitamin D supplements or a placebo. The team tracked the participants for around five years to measure the development of autoimmune conditions, including rheumatoid arthritis, autoimmune thyroid disease and psoriasis.

This revealed that a dose of 2000 international units (IU) of vitamin D per day reduced the development of autoimmune disease by 22 per cent, compared with the placebo (*British Medical Journal*, doi.org/gn9xdm). This is a larger dose than the 400 IU recommended by health bodies such as the UK's Department of Health and Social Care.

It is unclear how vitamin D prevents autoimmune disease, but we know it is processed in the body to produce an active form that can alter the behaviour of immune cells.

The team is now extending the trial to see how long the benefits last and hopes to start a new trial in younger people.

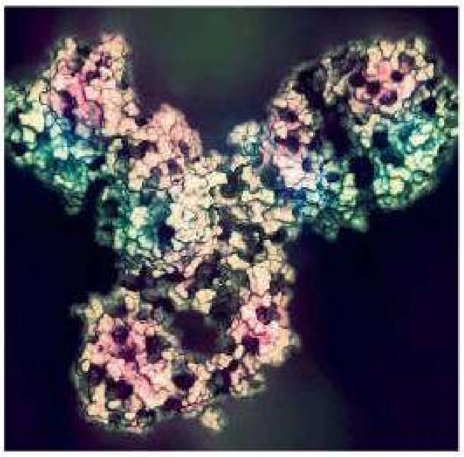
"I'm very excited and really quite bowled over by the results," says Costenbader. **CWo**

Viruses

Cancer drug could be way to clear out HIV

TODAY, HIV can be controlled, but for most people there is no cure because the virus can become dormant so HIV medicines have no effect. This could change, now that progress has been made in waking up dormant viruses.

People with HIV can take antiviral medicines that stop the virus from reproducing, giving them nearly normal lifespans. But HIV inserts copies of its genetic material into human immune cells, which then become dormant. As a result, people have to take the antivirals for life because if they stop, viruses inside the cells wake up and start infecting more and more immune cells.



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The idea that dormant viruses could be reactivated before being destroyed is sometimes known as a "kick and kill" strategy. In the latest work on this, Sharon Lewin at the University of Melbourne, Australia, and her team studied people with HIV who were also being treated for cancer with a fairly new drug: pembrolizumab, an antibody (pictured). They found the drug also makes HIV inside dormant immune cells wake up. In 32 people given pembrolizumab, HIV levels in their blood rose 1.6-fold (*Science Translational Medicine*, doi.org/hd4v).

But the approach needs further work, as strategies to kill immune cells with replicating HIV, such as vaccines and antibodies, are still in development. **Clare Wilson**

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Really brief

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Life survives in heat deep below seabed

Microbes have been found alive 1.2 kilometres below the sea floor where the mud is at 120°C. At such high temperatures, heat causes a lot of damage, so the cells may need fast metabolisms to repair themselves. No known microbe can survive above 122°C (*Nature Communications*, doi.org/hd3g).

Bitcoin safe from quantum hackers

Quantum computers would have to become much larger in order to break the algorithm that secures bitcoin. A quantum computer with 13 million qubits is needed to break the algorithm in 24 hours. Today's computers have about 125 qubits at most (*AVS Quantum Science*, doi.org/hd3b).

Bat evolution linked to ear bone change

A single bone in the inner ear is the only significant difference between the two major groups of bats, called Yinpterochiroptera and Yangochiroptera. Bats in the latter group have a certain ear bone peppered with large holes, allowing for more neurons to run from the ear to the brain (*Nature*, doi.org/gn9srd).

Astronomy

Mysterious signal beaming from afar

A STRANGE object in space is pulsing in a way never seen before. It may be an odd neutron star – the remnant of a stellar explosion.

Natasha Hurley-Walker at Curtin University in Perth, Australia, and her colleagues found the object using the Murchison Widefield Array (MWA), a radio telescope in Australia. After spotting a barrage of radio waves that seemed to appear and then disappear, they dug into archival data taken by the MWA in early 2018 and found 71 more pulses. With each pulse, the object – named GLEAM-X J162759.5-523504.3 and located about 4000 light years away – released huge amounts of energy.

It pulsed with a regular rhythm, brightening for 30 to 60 seconds once every 18.18 minutes. Nothing with a rhythm similar to this has been found before – most flashing radio objects in the sky pulse far faster, brightening and disappearing again in a matter of seconds.

The pulsing indicates that the object is probably spinning, and other measurements of its light hint that it must have a powerful magnetic field. This led the researchers to suspect that it may be a magnetar, a type of neutron star with a particularly strong magnetic field, but it isn't clear how a magnetar could rotate so slowly and shine so brightly (*Nature*, doi.org/hdv8).

"I was concerned that it was aliens, but… it [emits radiation] across a very wide range of frequencies, and that means it must be a natural process," said Hurley-Walker. **Leah Crane**

Medicine

JIAWEI GE

Robot gets to grips with delicate intestinal surgery

A MACHINE working mostly on its own has successfully performed keyhole surgery on the bowels of pigs for the first time, a significant step towards human trials.

Small parts of operations on people are often automated, but they tend to focus on rigid parts of the body that don't change shape, such as bone. Most robot surgery is controlled entirely by surgeons.

Justin Opferman at Johns Hopkins University in Maryland and his team programmed a similar robot to join the two ends of intestine after a section is removed, with limited human intervention.

The robot performed the surgery on four pigs, carrying out a total of 86 stitches. Two-thirds of the time, the robot placed the stitch autonomously, while the rest of the time it had to be guided into place manually to try the stitch again.

When the tissues were examined one week after surgery, the results were comparable with those achieved by human surgeons (*Science Robotics*, doi.org/hd4s). The operation is particularly onerous because any leak can cause catastrophic complications.

Opferman says the trial is the first step towards autonomous surgery in humans, although this is probably decades away. **Matthew Sparkes**

Animal behaviour

Home is where the magnetic field tilts

SOME birds rely on Earth's magnetic field to navigate and it seems that one species can use it to judge when it has got home.

One issue for birds using the field is that its direction and strength change over time – a problem if you must return to a specific site. Now, Joe Wynn at the University of Oxford and his team have found that the Eurasian reed warbler (*Acrocephalus scirpaceus*) appears to use the inclination of the field above the planet's surface, or how much it slopes from the horizontal, as a sort of stop sign. Inclination, compared with other magnetic features, drifts the least.

Wynn and his team used nearly 80 years of location data for the birds' breeding sites in Europe after returning from winter in Africa. The information showed that birds didn't always return to the exact site, but often a different site a few tens of kilometres away.

By comparing the fluctuations in breeding sites over time with different models of where the birds might be expected to return if they relied on various properties of Earth's shifting magnetic field, it became clear changes in the field inclination were the most likely guide for the birds (*Science*, doi.org/hd48). **Alex Wilkins**

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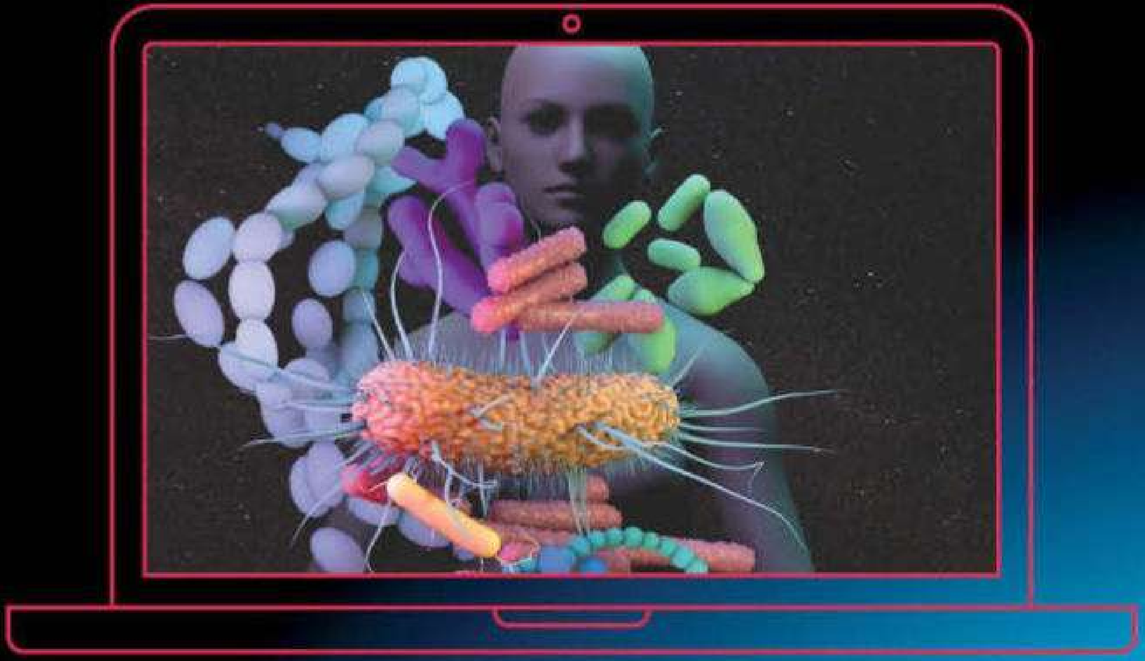

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Comment

Saving the reefs

Coral gardening projects are more popular than ever, but they are a distraction from the real solutions, says **Catherine Collins**

MICHELLE D'URBANO

CORAL reefs in Australia are set to experience another mass bleaching event due to ocean temperature rises – the fourth in seven years – according to a forecast released by the US National Oceanic and Atmospheric Administration. Reefs need serious efforts to help them to cope and survive, but our endeavours are currently misplaced, focusing on the glamorous rather than the effective.

Coral gardening projects, where coral species are cultivated and cared for by humans in floating nurseries before being planted back onto the reef, are popping up around the world. While there are some advantages to this approach – we can choose parent corals that are more likely to survive warmer temperatures in a warming ocean, for example – it is riddled with problems.

For a start, genetics is rarely so straightforward. The same gene that codes for heat tolerance might also make corals more susceptible to a particular disease, for instance, or more likely to fail reproductively. Stacking the genetic odds in the coral's favour in terms of heat tolerance might not necessarily be a winning strategy over the long term.

One of the methods used is called fragging, in which a small piece of coral is broken off the parent, much like a cutting, and grows to form a new coral. Although it can work, it is more like a quick fix. The resulting reef can easily lack genetic diversity if all the "cuttings" are genetically identical – and that means the corals could be more likely to perish in changing environmental conditions.

Most coral reef gardening projects are small, and haven't been running for very long. More than two-thirds of all coral reef restoration projects have lasted for 18 months or less, meaning that their long-term effects aren't well understood. And most projects have been carried out over small areas, often 100 square kilometres or less. We can't rely on coral gardening to save reefs over large areas and the longer term.

All is not lost. There are actions that will make a difference for coral reefs and we need to prioritise them immediately.

The first is creating and enforcing marine protected areas. The UN described overfishing as "the most pervasive and immediate" threat to reefs in its 5th Global Biodiversity Outlook report in 2020. Coral ecosystems rely on the marine life that surrounds them – coral fish faeces contains algae that corals need to survive, for example, and parrot fish feed on seaweed that would otherwise suffocate reefs.

When parts of the ocean are completely free from human activities that can give coral reefs the space and the time needed to naturally recolonise and recover what they have lost, including much of the genetic diversity and biodiversity of the original reef.

But marine protected areas aren't enough on their own. High ocean temperatures will result in bleached corals even if the area is protected. Coral reefs are likely to decline by 50 to 90 per cent by 2050 due to ocean warming even if we succeed in keeping atmospheric warming to well below 2°C above pre-industrial levels, as set out in the Paris Agreement. That is why fast action is needed now to curb fossil fuel emissions and keep us well below that 2°C mark.

If we truly want our coral reefs to survive and thrive, we must combat the source of the problem. What reefs really need is for us to drastically reduce our fossil fuel emissions immediately and protect the reef fish and biodiversity that nourish and sustain coral ecosystems. Everything else is a distraction. ▮

Catherine Collins is a science journalist based in Brussels, Belgium

This changes everything

The robo car uprising

Numbers of self-driving vehicles are going up rapidly in California. It is a trend that might just lead to some unexpected outcomes, writes **Annalee Newitz**

DRIVING in San Francisco is like watching a robot uprising in the making. Last week, I was crossing an intersection, turning from one major downtown thoroughfare onto another, and realised that my vehicle was surrounded by four experimental self-driving cars.

They weren't exactly difficult to spot, their bumpers encrusted with radar and other sensors, their roofs topped by enormous lidar rigs, including bulbous, whirling cameras shaped like turrets.

These kinds of cars aren't uncommon in San Francisco and Silicon Valley to the south of the city. But their numbers are growing fast, bringing many questions with them. The California Department of Motor Vehicles reported that there were 900 self-driving vehicles registered in the state in November 2021. As of December 2021, the number had jumped by a huge 55 per cent to 1400.

Most of them are Waymo vehicles, fitted out by Alphabet, Google's parent company. And most cruise the streets of the San Francisco Bay Area using sensors to gather data on road conditions. The idea is that the data will be used to improve the algorithms that guide these cars through every possible hazard and traffic snarl.

Here in California, safety rules require that self-driving vehicles carrying people on public roads must have someone behind the wheel, even if they don't do much. But in Arizona, self-driving taxis are ferrying people around with nobody in the driver's seat.

This has led to some hilarity, as in the case last year when a passenger recorded a video of his Waymo taxi becoming confused by orange road cones. First the poor car simply stopped, blocking the road. Then, when roadside assistance from Waymo arrived to intervene, it tried to escape twice, pulling away from the person sent to help.

In that case, nobody was hurt and there was no crash. But when self-driving cars go wrong the results can be devastating. In 2018, a woman named Elaine Herzberg was pushing a bicycle across a road in Arizona when she was struck by an Uber car in self-driving mode, albeit with a safety driver in it. Herzberg died of her injuries.

Because of incidents like this, truly self-driving cars are unlikely to advance beyond limited taxi-like services for decades. Even Waymo, which agreed a deal in December with automaker Geely to produce a fleet of self-driving vans designed for ride-share customers, has been vague about the launch date. Promotional materials say the vans will arrive "in the years to come".

> **"First the poor car simply stopped. Then, when roadside assistance arrived, it tried to escape twice"**

Other companies have simply given up. Uber announced in 2020 that it was scrapping its long-touted plan to develop its own driverless vehicles.

So if all those sensor-clad cars on the streets of San Francisco aren't about to start whisking me off to the grocery store, what are they good for?

Obviously Waymo is hoping that there is still a market for future ride-share firms, one with fewer pesky human drivers that sometimes demand pay rises. If they can just get enough data, maybe their cars will never get caught out by traffic cones again.

In addition, a number of companies are developing self-driving delivery trucks that can use simple, predetermined freeway routes to deliver goods hundreds of miles away. Because these trucks stick to major roads, they may be easier to program.

As economists like Brad DeLong at the University of California, Berkeley, are fond of pointing out, automation giveth and taketh away. If these companies are right, there will be fewer human drivers, but there will also be new jobs for people to develop and maintain self-driving cars and for workers to keep the roads optimised for the AI fleet.

There is an even weirder possibility, however: self-driving cars really could lead the robot uprising. For decades, roboticists have argued that human-equivalent consciousness can only evolve if it is "embodied". A brain in a box will never think like a person. But a brain in a body? That could work.

After all, nothing is more human than spending your first few years of life learning not to run into things and avoiding danger. This is one reason why, for example, researchers at Stanford University are putting AIs inside simulated "bodies" to help them get smarter.

It could turn out that a giant metal body on wheels is the missing link that we need to develop artificial general intelligence. Maybe we saw the first inkling of that future in the unfortunate adventures of that Waymo taxi that rolled away from the person who attempted to get it back to work.

It makes you wonder. What are the self-driving car firms of the world going to do when their vehicles go on strike? ▮

Annalee Newitz is a science journalist and author. Their latest novel is *The Future of Another Timeline* and they are the co-host of the Hugo-nominated podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

Annalee's week

What I'm reading
Devil House *by John Darnielle, a moving, funny novel about Satanic panic and the early internet*

What I'm watching
The new series Naomi, *about a girl who runs a Superman fan site – and then discovers that she is an alien just like her hero*

What I'm working on
A story about all the weird misconceptions we have about Neanderthals

This column appears monthly. Up next week: Laura Spinney

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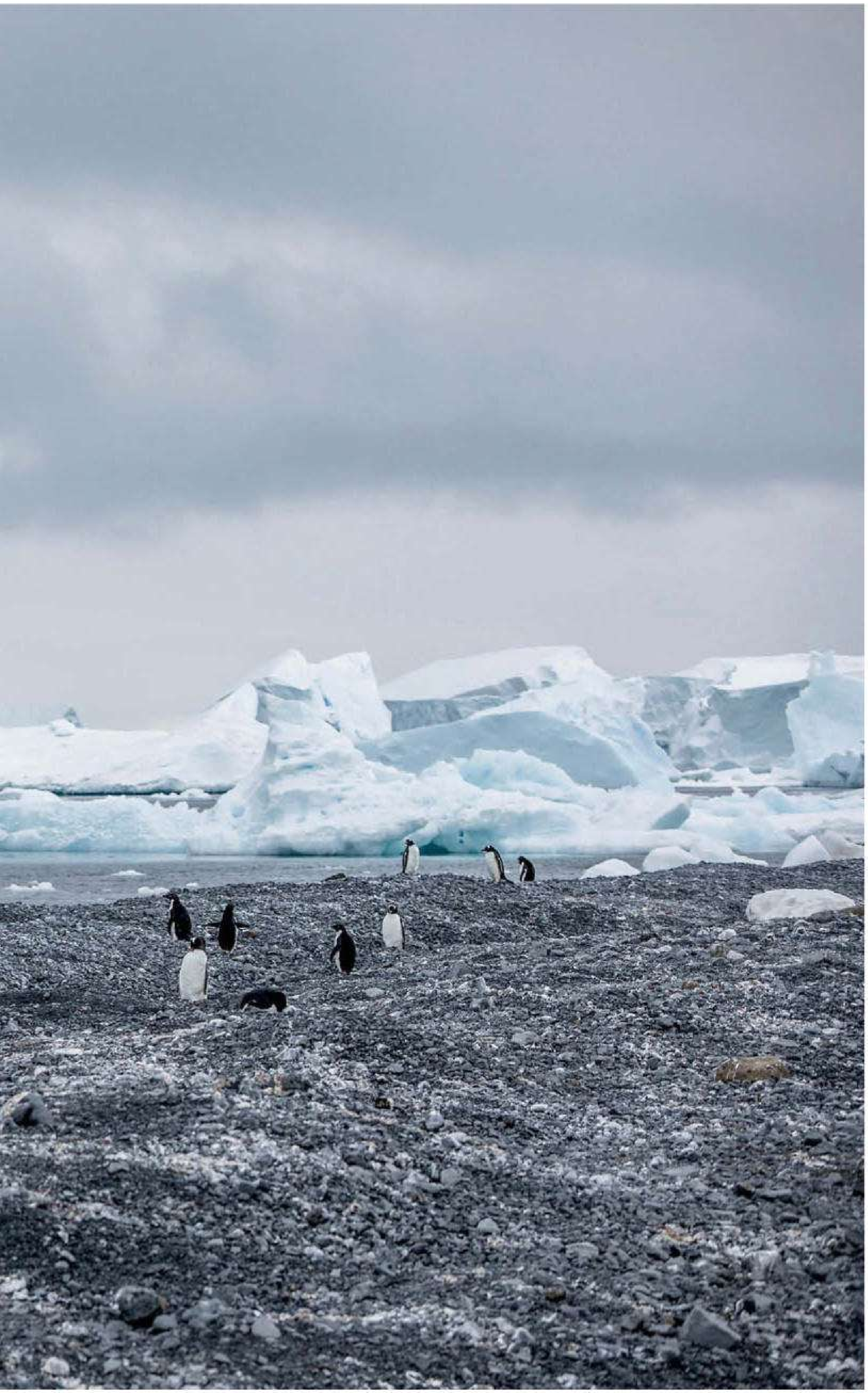

Gone south

Photographer Tomás Munita/ Greenpeace

THIS is a newly discovered colony of gentoo penguins on Andersson Island off the Antarctic Peninsula, photographed by Tomás Munita.

The animals and their 75 nests were found by researchers from Stony Brook University in New York during a Greenpeace expedition to the frigid region. The team is surveying, and filming, penguins on archipelagos previously unexplored by foot, to uncover the extent of the effect of climate change on populations of penguins. The birds are considered to be "sentinel species", in this case alerting us to the impact of a warming world.

Finding gentoos so far south isn't normal. These penguins usually prefer warmer regions such as the sub-Antarctic and the Falkland Islands, where a large population of them lives.

Climate change, however, is opening up new territories. As temperatures rise and more ice melts, the eastern side of the Antarctic Peninsula – once considered too icy and harsh for gentoos to survive and thrive – has become more habitable for them.

This changing distribution of penguins is just one aspect of transformations across the entire Antarctic ecosystem, which is undergoing some of the most rapid warming in the world.

Gege Li

Editor's pick

Yes, obesity is about much more than food

8 January, p 21

From Jon Arch, Welwyn Garden City, Hertfordshire, UK

David Ludwig says it makes more sense to argue that a teenager's growth spurt causes increased eating than that increased eating causes the growth spurt. Similarly, he says, obesity due to intrinsic factors may lead to excess energy intake, rather than vice versa.

I have often thought that nobody would use the absurd argument that elephants are bigger than mice because they eat more. Genetics explains this. So why is genetics so often ignored as a cause of obesity? The problem, of course, is that we can't change genetics, so we have to alter non-genetic factors.

I don't want to live on a diet that is low in carbohydrate and high in fat – Ludwig's solution. Far better is changing my expectations of satiety and eating habits, as explained in the previous week's article by David Robson (1 January, p 36). It seems to work for me.

Firms are already hacking employees' personalities

15 January, p 46

From Penny Jackson, Barrow-in-Furness, Cumbria, UK

In "How to hack your personality", you say "companies might pressure staff to undergo personality change training against their will".

This sort of thing already happens on a regular basis. Many firms try to push "mindfulness" and "resilience" training on staff, so that instead of trying to fix the problems in the work environment, they can send people on courses to "fix" their reactions to stress instead.

I have also seen a few seminars and "motivational" speakers claim that anyone can control their stress responses, and then employers expect people to just do that because someone said it was possible, when actually this takes extensive therapy.

The other great global crisis we must tackle

29 January, p 20

From Steve Arlington, chairman of the advisory board, Pistoia Alliance, London, UK

As your report on the pandemic of antimicrobial resistance (AMR) shows, this is already killing millions of people around the world. Without coordinated international projects, the problem is only going to worsen.

The serious consequences of AMR have long been known, but the problem has yet to be tackled with any urgency. In light of these findings, we need global action.

We need a renewed focus driven by public-private partnerships and philanthropic funding. Crucially, governments and international bodies must incentivise research, something the Pistoia Alliance, a non-profit group, advocates. Without a significant and prolonged increase in investment into AMR research, the cost to national economies and public health will be devastating.

Don't treat animals as spare parts for people

15 January, p 7

From Julia Baines, science policy adviser, People for the Ethical Treatment of Animals (PETA UK)

You report on the first pig heart transplant into a person, in the US. Using animals as warehouses for spare parts is morally wrong.

Pigs are sentient, complex, intelligent individuals that, like any animal, shouldn't be raised and raided for their organs. People who need a transplant need a human organ and changing US laws to presume consent for organ donation, as is the case in England, would make many more organs available, saving lives and sparing more animal suffering.

From Adam Walsh, Humane Research Australia

As science communicators, we must be considerate of the language we use to convey ideas and information. Terms such as "donated" imply an explicit decision by an individual. We must admit and clearly convey that animals aren't able to give their consent and, as such, aren't able to donate their organs.

Gas crisis fix mustn't encourage energy use

15 January, p 20

From Eric Kvaalen, Les Essarts-le-Roi, France

With regard to lowering the impact of high energy prices on consumers, remember that we want to cut the use of fossil fuels, so policies to alleviate this problem shouldn't promote energy use.

If direct payments are made to consumers, they shouldn't be linked to energy consumption – people should have the right to choose how to spend the money, but everyone should pay for energy at the same rate.

From Chris Mullins, Edinburgh, UK

According to renewable power group Octopus Energy, "all energy sources in the UK, from wind to solar to fossil fuels, are being sold based on the high price of gas imports – the higher price of 'brown' electrons artificially putting up the price of 'green' ones as well". However, about 40 per cent of our gas isn't imported, it comes from the North Sea.

The price we pay for this gas has increased at least fourfold since last October compared with the average price over the past five years "because of the (very flawed) way the market is currently set up", according to Octopus Energy. Windfall taxes could be applied to at least halve the projected price increase in domestic energy.

AIs may be all at sea when it comes to drifting fish

15 January, p 10

From Keith Hiscock, Plymouth, UK

David Hambling reports on the impressive accuracy of AI and mathematical modelling in predicting where drifting devices end up in the ocean, and speculates about its possible application to fish larvae.

Some ecologists might try to use this to predict the trajectory, speed and landing site for larvae. But that won't work unless the system can take account of the fact that larvae and young fish use all sorts of clues (olfactory, auditory and visual especially, and maybe magnetic) to get to a suitable habitat or find others of their species. These animals may also move up and down the water column to pick up currents going in a desired direction. Without accounting for these factors, use of such models for this purpose would be naive.

Don't forget the global warming burp effect

Letters, 15 January

From Bruce Denness, Niton, Isle of Wight, UK

Colin Heath's belief that replacing livestock with trees wouldn't deliver a sufficiently fast reduction of greenhouse gases because trees take 25 years to grow overlooks the immediate elimination of the animals' flatulence.

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters
Letters sent to New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT will be delayed

For the record

- **The 2013 novel *Life After Life* is by Kate Atkinson (15 January, p 2).**

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Climate fiction's call to arms

So-called cli-fi is galvanising readers into action with dark, yet all-too-possible futures. **Bill McGuire** picks some of the best

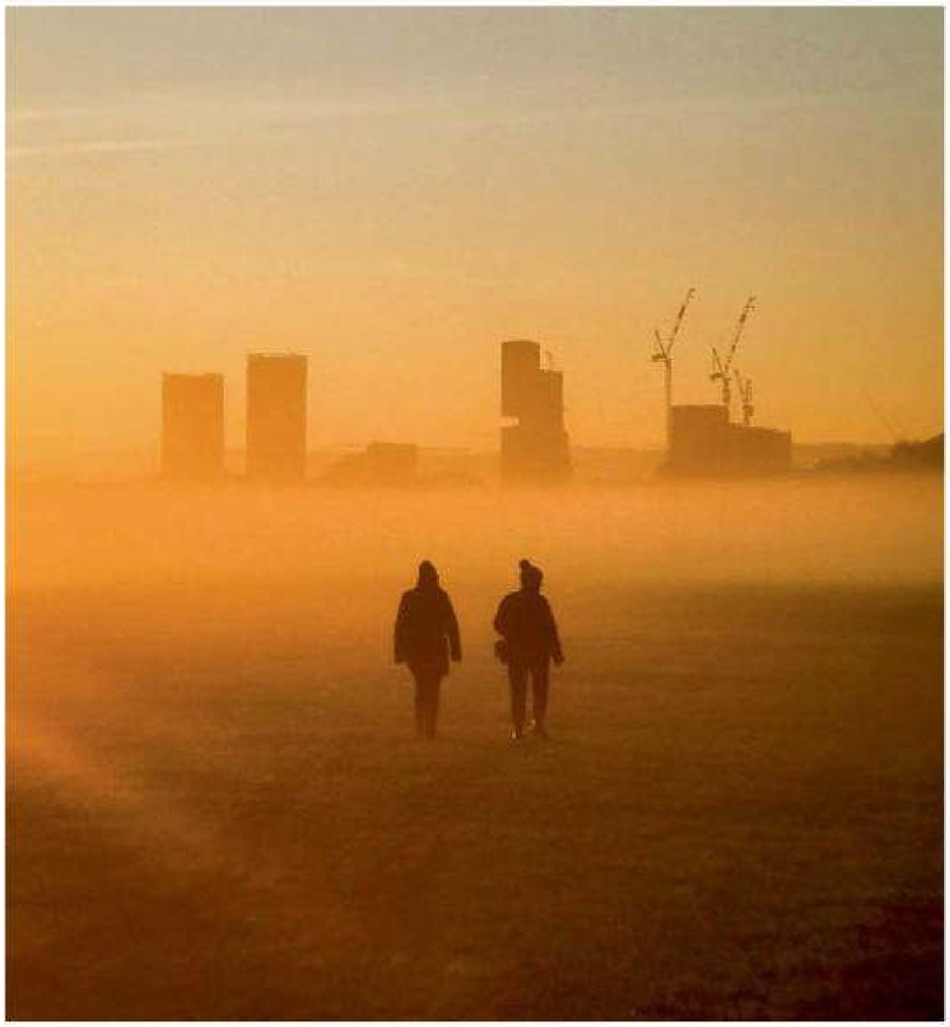
SCIENTIFIC papers, however well-written, rarely carry the emotional weight of a good story. Stories have been the prime means of imparting knowledge and warnings throughout human history. Even in today's data-rich world, they hold a visceral clout that no amount of graphs, charts or figures can replace.

As a volcanology and climate researcher, I have spent more than 30 years communicating the calamitous future that could lie in wait should we fail to take action on climate change. But it wasn't until I published my first novel, *Skyseed*, in 2020 that I realised the power of storytelling to get across the urgency of the situation.

This use of narrative as a means to galvanise action on climate change has become increasingly common, and the rapidly growing body of work on the subject is now recognised as its own literary genre. Climate fiction, or cli-fi (a term coined in 2007 by journalist and literary theorist Dan Bloom), has been around for a while.

However, as global warming and extreme weather have become a part of everyday life, and the appetite for action has grown, cli-fi has truly come of age. From the genre's relatively slow start in the mid 2000s, the shelves of bookshops are now beginning to sag under the weight of new speculative climate tales, aimed at both adult and young adult readers.

As the genre gained ground, overenthusiastic fans and critics have reached back into literary deep time to corral any number of classics into the cli-fi fold. Notable examples include *The Drought* and *The Drowned World* by J.G. Ballard, and Jules Verne's *The Purchase of the North Pole*, a cautionary tale published in 1889 on the perils of geoengineering.



Cli-fi provides visions of the future that aren't yet too late to change

JORN GEORG TOMTER/GETTY IMAGES

For me, though, this broadening of the genre is misguided. It dilutes a growing body of work that is, and should remain, very much of the late 20th and early 21st centuries.

That is because there is an important difference between earlier tales of climate turmoil and more contemporary works.

> **"Cli-fi immerses its readers in futures that, without urgent action, will face our children and their children"**

While older stories describe environmental outcomes we are now coming to expect with climate change, they don't necessarily link human activities to environmental collapse. That is very much the point of cli-fi.

Without exception, today's writers make this connection abundantly clear and raise important questions about what we should do next.

As such, modern cli-fi is fiction with a purpose: to immerse its readers in futures that, without urgent action, will face our children and their children. By bringing these horrific scenarios to life, it seeks to spur us into action, encouraging us to do our bit to ensure that they never come to pass. Climate fiction is nothing less than a call to arms.

Among the most unsettling stories are those, such as Paolo Bacigalupi's *The Windup Girl* and Kim Stanley Robinson's *New York 2140*, that paint pictures of life in a future world that, as in the pandemic, is superficially normal, yet in a climate-changed world is, in so many ways, scarily different.

My cli-fi contribution, *Skyseed*, is an eco-thriller about a clandestine climate experiment that goes disastrously wrong. The message is that tinkering with an already failing climate is a very bad idea.

Yet the genre isn't all wall-to-wall doom and gloom. Cli-fi is a broad church, so, alongside the horrors of *The Collapse of Western Civilization* by Naomi Oreskes and Erik Conway, there is the dark humour of Karl Taro Greenfeld's *The Subprimes* and the political focus of Robinson's *Science in the Capital* trilogy.

Others provide tough stories shot through with seeds of hope, notably Robinson's recent *The Ministry for the Future*, which invokes an organisation that advocates for future generations and the protection of all life on Earth, and *Blackfish City*, Sam Miller's addictive, post-climate collapse tale about a floating city within the Arctic circle.

I also recommend *The High House* by Jessie Greengrass, a story of ordinary folk against the background of a flooded East Anglia in the UK, and Alexandra Kleeman's *Something New Under the Sun*, set in a desiccated California, where the corporate vultures are beginning to circle.

As our lives begin to collide head-on with the climate emergency, let's hope that cli-fi remains in the world of fiction and, thanks to the action of present-day generations, never comes to represent the reality of the world around us. ▮

Bill McGuire is professor emeritus of geophysical and climate hazards at University College London and author of the novel *Skyseed*

How stuff works

To know our future, we need to focus on understanding the world we live in now, finds **Simon Ings**

Book

How the World Really Works: A scientist's guide to our past, present and future

Vaclav Smil

Viking

IN SUCH a complex world, no one can be expected to understand everything. But for energy expert Vaclav Smil, there are limits. In his view, it is inexcusable that most of us don't know the first thing about the basic workings of modern life and the technologies that keep us all alive. It's not all rocket science, he says. "Appreciating how wheat is grown or steel is made... are not the same as asking... somebody to comprehend femtochemistry."

Smil deplores the way that Western culture disproportionately rewards work that is removed from the material realities of life on Earth. Most of all, he is concerned that the general public is abandoning its grip on reality. *How the World Really Works* is Smil's attempt to redress the balance, showing the fundamentals of how food is grown, how the built environment is made and maintained, and how all of this is powered.

Smil believes it is worth understanding what might seem like outdated technologies given that the building blocks of our lives won't change significantly over the next 20 to 30 years. Most of our electricity is still generated by steam turbines, invented by Charles Parsons in 1884, or by gas turbines, first commercially deployed in the late 1930s, he writes. And many of the trappings of the industrial world still hinge on the production of ammonia, steel, concrete and plastics, all of which currently require fossil fuels for their production. Even the newest technologies – AI, electric cars, 5G and space tourism – get most of their energy from fossil fuel-based turbines, says Smil.

Alternative methods are on their way, of course, but they will take decades to fully establish. Coal displaced wood relatively easily in the early 20th century, but it will probably take longer to bring in renewables because global energy demand is now an order of magnitude higher.

Given the irrefutable evidence of climate change, does this mean that Western civilisation, so hopelessly dependent on fossil fuels, is doomed?

Perhaps, but Smil would prefer that we concentrate on practical solutions, rather than wasting our energies on complex socio-economic forecasts. In his view, such forecasts will get less accurate over time because "more complex models combining the interactions of economic, social, technical, and environmental factors require more assumptions and open the way for greater errors".

How the World Really Works neither laments the possibly imminent end of the world, nor bloviates about the potentially transformative powers of the AI Singularity. Indeed, it gives no quarter to such dramatic thinking, be it apocalyptic or techno-utopian.

Instead, in an era where specialisation is seen as the pinnacle of knowledge, Smil is an unapologetic generalist. "Drilling the deepest possible hole and being an unsurpassed master of a tiny sliver of the sky visible from its bottom has never appealed to me," he writes. "I have always preferred to scan as far and as wide as my limited capabilities have allowed me to do."

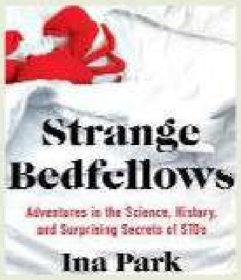
He chooses to explain the workings of the world as it is today, from energy to food, materials, the biosphere, globalisation and the perception of risk. He covers sizeable ground that other commentators ignore. It is a grumpy, pugnacious account that, I would argue, is intellectually indispensable in the run up to this year's COP27 climate conference in Egypt. In short, *How the World Really Works* fully delivers on the promise of its title. It is hard to formulate any higher praise. ▮

Whether we like it or not, the industrialised world in still heavily dependent on fossil fuels

DEEPOL BY PLAINPICTURE/MONTY RAKUSEN

Simon Ings is a writer based in London

Don't miss



Strange Bedfellows

Adventures in the Science, History, and Surprising Secrets of STDs

Ina Park

Read

Strange Bedfellows accompany many of us through our lives, yet most of us know next to nothing about common sexually transmitted infections. Ina Park aims to change all that in this upbeat look at the science of STIs.

Visit

Audubon's Birds of America is a chance to see this rare, hand-coloured natural history book and to learn more about its controversial creator, John James Audubon. It is on show at the National Museum of Scotland in Edinburgh from 12 February.

Watch

Death by Shakespeare sees chemist Kathryn Harkup reveal the science behind some of the grisly methods used by the Bard to kill characters in his plays. Online talk by the Royal Institution on 10 February at 7pm GMT.

NATIONAL MUSEUMS SCOTLAND; SHUTTERSTOCK/TRIFF

The games column

What's new for 2022

This year sees a good haul of new games, with post-apocalyptic adventures, zombies, aliens and a little light relief thanks to a puzzle-solving cat, says **Jacob Aron**

Jacob Aron is *New Scientist*'s deputy news editor. Follow him on Twitter @jjaron

Games

Horizon Forbidden West
Guerrilla Games
PlayStation 4 and 5

Star Trek: Resurgence
Dramatic Labs
PC, PlayStation 4 and 5, Xbox Series X/S

Starfield
Bethesda Game Studios
PC, Xbox Series X/S

The Callisto Protocol
Striking Distance Studios
PC, PlayStation 5, Xbox Series X/S

STALKER 2: Heart of Chernobyl
GSC Game World
PC, Xbox Series X/S

Stray
BlueTwelve Studio
PC, PlayStation 4 and 5

GUERRILLA GAMES

In *Horizon Forbidden West*, animalistic robots are both friend and foe

THE early weeks of the year are traditionally a slow time for video game releases, so I thought I would use this month's column as a chance to look ahead to some of the titles I am looking forward to playing in 2022.

First up is *Horizon Forbidden West*, out this month. It is the sequel to *Horizon Zero Dawn*, set in a post-apocalyptic future dominated by robot creatures that mimic everything from deer to *Tyrannosaurus rex*. The first game was all about uncovering the origin of the apocalypse while hunting down machines for parts, and I am intrigued to see where the story goes next.

For a lighter and perhaps more hopeful future, I have my eye on *Star Trek: Resurgence*, due in the first half of the year. It has been decades since we had a decent *Star Trek* video game, and with the franchise seeing a resurgence on TV, I am hoping this new game will finally deliver the goods. You will play as two Starfleet officers aboard a *Star Trek: The Next Generation*-era ship and it looks to be a good mix of action and diplomacy, just as you would expect from *Star Trek*.

One of the biggest releases expected in November is *Starfield*, a new role-playing game from Bethesda, the developers of the *Fallout* and *The Elder Scrolls* series. These are immersive games with huge worlds to explore in a post-apocalyptic and fantasy setting respectively, and are some of the most popular titles around.

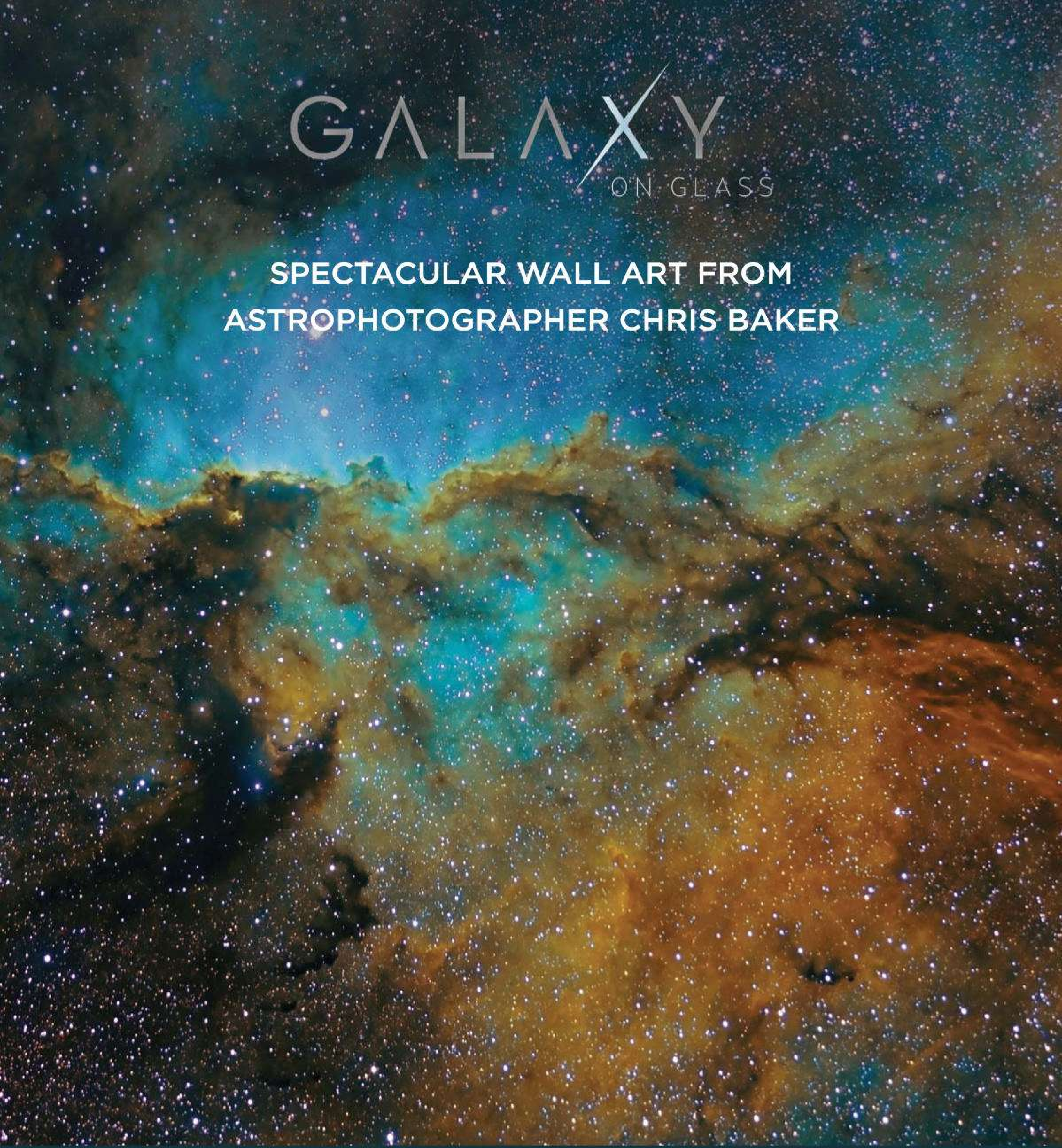
> **"It has been decades since we had a decent *Star Trek* video game. I'm hoping *Star Trek: Resurgence* delivers"**

In *Starfield*, Bethesda has applied the same formula to a space exploration story set in the 24th century. It has described the game as both a "Han Solo simulator" and "NASA-punk", meaning that the spacecraft and other technologies depicted in *Starfield* can trace their roots to those in use today. I can see myself spending dozens of hours exploring the solar system. The only potential fly in the ointment is that Bethesda games are notoriously buggy at launch due to their sprawling complexity. Time will tell.

Another upcoming game, *The Callisto Protocol*, is also set in the 24th century, in a prison colony on Jupiter's moon Callisto. An alien-like creature is stalking the facility and you have to escape. Development is being led by Glen Schofield, co-creator of sci-fi horror series *Dead Space*, and this new title seems like a nice evolution of those previous games.

In December comes *STALKER 2: Heart of Chernobyl*, yet another post-apocalyptic sequel – but let's be honest, video game developers are very keen on apocalypses. This one is set around the Chernobyl exclusion zone in Ukraine, in a world where a second explosion at the doomed nuclear power plant created strange and valuable artefacts, along with a bunch of zombies and other monsters. You play as a stalker, part of a group of people who are hunting down these artefacts while also trying to make it out alive.

Finally, on a totally different tack, I am really looking forward to seeing more of *Stray*, due out in October. You play as a cat that befriends a flying drone while exploring a cyberpunk city populated by robots. Developer BlueTwelve Studio has revealed few details beyond that, but trailers released so far suggest that the game will present a cat's-eye view of the world as the feline trots around among droids, using cat skills to solve puzzles, while looking endearingly nonchalant about the whole thing. ■



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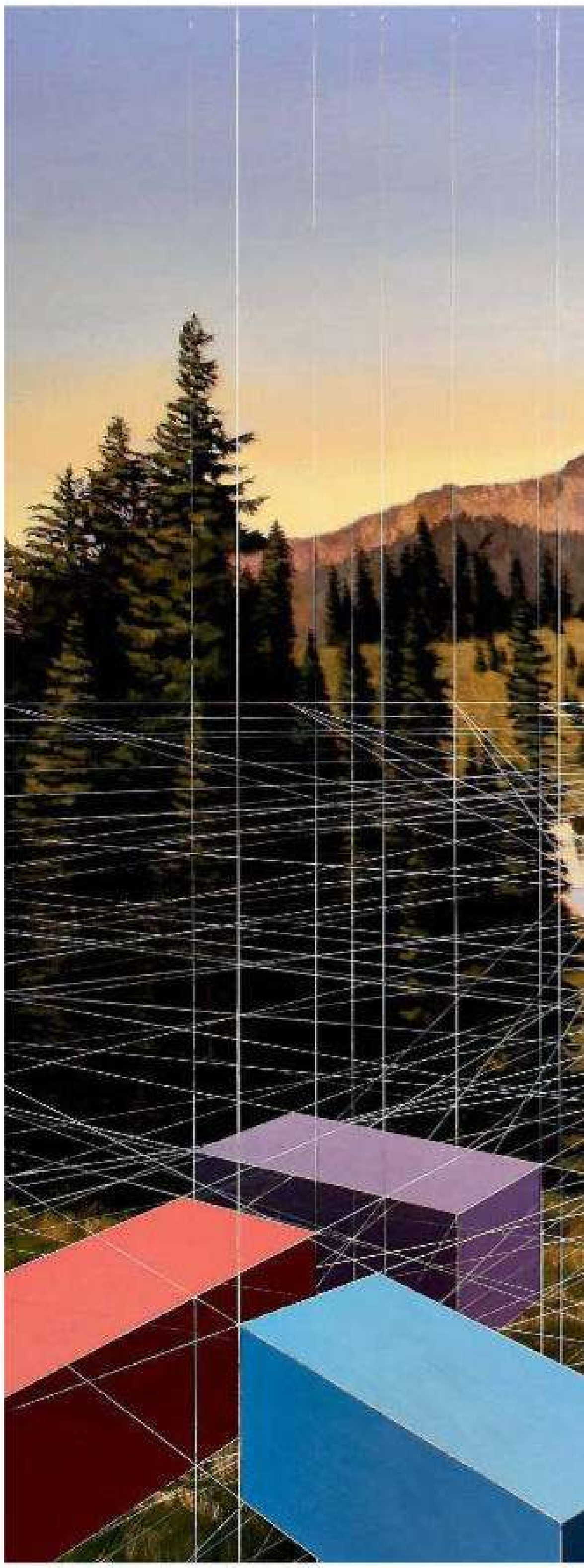
Quantum perspective

Our efforts to see reality from multiple points of view at once are revealing the strange part we all play in creating it, says **Amanda Gefter**



MARY IVERSON

IMAGINE approaching a Renaissance sculpture in a gallery. Even from a distance, it looks impressive. But it is only as you get close and walk around it that you begin to truly appreciate its quality: the angle of the jaw, the aquiline nose, the softness of the hair rendered in marble.

In physics, as in life, it is important to view things from more than one perspective. As we have done that over the past century, we have had plenty of surprises. It started with Albert Einstein's theory of special relativity, which showed us that lengths of space and durations of time vary depending on who is looking. It also painted a wholly unexpected picture of the shared reality underneath – one in which space and time were melded together in a four-dimensional union known as space-time.

When quantum theory arrived a few years later, things got even weirder. It seemed to show that by measuring things, we play a part in determining their properties. But in the quantum world, unlike with relativity, there has never been a way to reconcile different perspectives and glimpse the objective reality beneath. A century later, many physicists question whether a single objective reality, shared by all observers, exists at all.

Now, two emerging sets of ideas are changing this story. For the first time, we can jump from one quantum perspective to another. This is already helping us solve tricky practical problems with high-speed communications. It also sheds light on

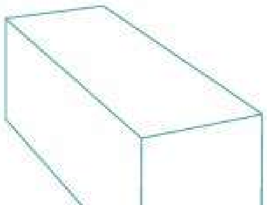
whether any shared reality exists at the quantum level. Intriguingly, the answer seems to be no – until we start talking to each other.

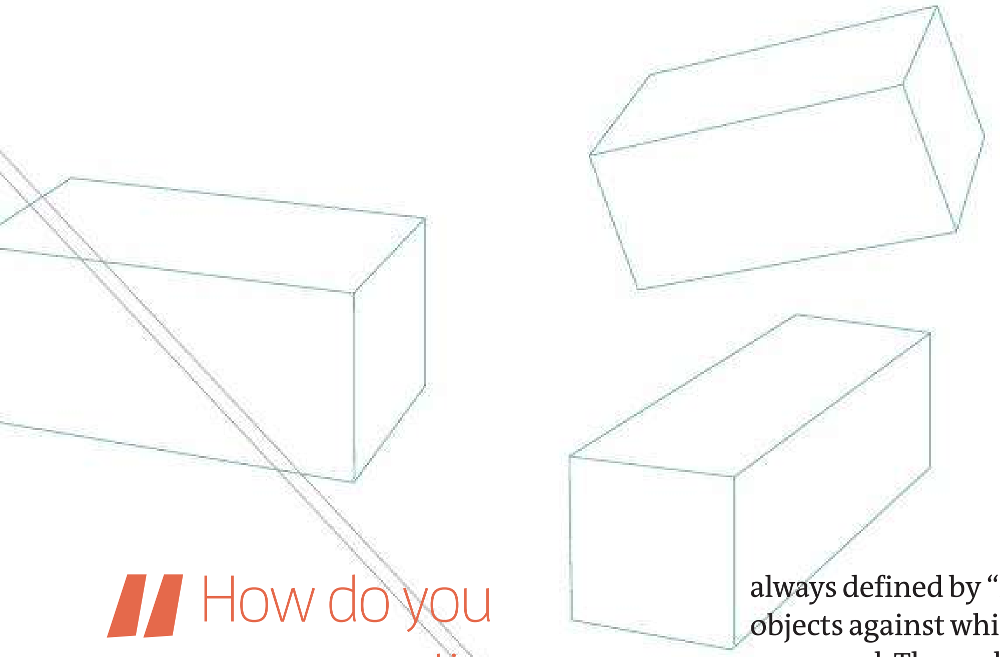
When Einstein developed his theory of relativity in the early 20th century, he worked from one fundamental assumption: the laws of physics should be the same for everyone. The trouble was, the laws of electromagnetism demand that light always travels at 299,792 kilometres per second and Einstein realised this creates a problem. If you were to race alongside a light beam in a spaceship, you would expect to see the beam moving far slower than usual – just as neighbouring cars don't look to be going so fast when you are zipping along the motorway. Yet if that was the case, the laws of physics in that perspective would be violated.

> "In the quantum world, there has never been a way to reconcile different perspectives and glimpse the shared reality beneath

Einstein was convinced that couldn't happen, so he was forced to propose that the speed of light is constant for everyone, regardless of how fast they are moving. To compensate, space and time themselves had to change from one perspective to the next. The equations of relativity allowed him to translate from one observer's perspective, or reference frame, to another, and in doing so build a picture of the shared world that remains the same from all perspectives.

He went on to develop these ideas into general relativity, which remains our best theory of gravity. But it isn't the whole story. In Einstein's writings, reference frames are





> "How do you measure time with a clock that is entangled, or distance with a ruler that is in multiple places at once?"

always defined by "rods and clocks", physical objects against which space and time are measured. These objects are, however, governed by a different theory altogether.

Quantum theory deals with matter and energy and is even more successful than relativity. But it paints a deeply unfamiliar picture of reality, one in which particles don't have definite properties before we measure them, but exist in a superposition of multiple states. It also shows that particles can become entangled, their properties intimately linked even over vast distances. All this puts the definition of a reference frame on shaky ground. How do you measure time with a clock that is entangled, or distance with a ruler that is in multiple places at once?

Quantum physicists usually avoid this question by treating measuring instruments as if they obey the classical laws of mechanics developed by Isaac Newton. The particle being measured is quantum; the reference frame isn't. The dividing line between the two is known as the Heisenberg cut. It is arbitrary and it is moveable, but it has to be there so that the measuring device can record a definite result.

Consider Schrödinger's cat, the thought experiment in which an unfortunate feline is in a box with a radioactive particle. If the particle decays, it triggers a hammer that breaks a vial that releases a poison that kills the cat. If it doesn't, the cat lives. You are outside the box. From your perspective, the contents are entangled and in a superposition. The particle both has and hasn't decayed; the cat is both dead and alive. But, as in relativity, shouldn't it be possible to describe the situation from the perspective of the cat?

This conundrum has long bothered Časlav Brukner at the Institute for Quantum Optics and Quantum Information in Vienna, Austria. He wanted to understand how to see things from multiple points of view in quantum theory. Following Einstein's lead, he started from the assumption that the laws of physics must be the same for everyone, and then developed a way to mathematically switch between quantum reference frames. If we could describe a situation from either side of the Heisenberg cut, Brukner suspected that some truth about a shared quantum world might emerge.

Think inside the box

What Brukner and his colleagues found in 2019 was a surprise. When you jump into the cat's point of view, it turns out that – just as in relativity – things have to warp to preserve the laws of physics. The quantumness previously attributed to the cat gets shuffled across the Heisenberg cut. From this perspective, the cat is in a definite state – it is the observer outside the box who is in a superposition, entangled with the lab outside. Entanglement was long thought to be an absolute property of reality. But in this new picture, it is all a matter of perspective. "What is quantum and what is classical depends on the choice of quantum reference frames," says Brukner.

Jacques Pienaar at the University of Massachusetts says all this allows us to rigorously pose some fascinating questions. Take the well-known double-slit experiment, which showed that a quantum particle can

Flying qubits

Networks of cables that carry quantum information are already being set up around the world as a prototype quantum internet. These networks transport information in the form of qubits, or quantum bits, which can be encoded in the properties of particles – typically in a quantum property called spin. One person sends a stream of particles to another, who then measures their spin to decode the message.

Except, not so fast. To be a useful means of communication, these particles must travel at close to the speed of light. At such speeds, a particle's spin gets "quantum entangled" with its momentum in such a way that if the receiver only measures the spin, information will be lost. "This is serious," says Flaminia Giacomini at the Perimeter Institute in Canada. "The qubit is the basis for quantum information, but for a particle moving at very high velocities, we can no longer identify a qubit." As if that weren't enough of a problem, each qubit doesn't move at one definite speed: thanks to quantum mechanics, it is in what is known as a superposition of velocities.

The rules of quantum reference frames developed by Časlav Brukner (see main story) could be the answer. Giacomini has shown how the rules can be used to jump into the particle's reference frame, even when the particle is in a superposition. From that perspective, it is the rest of reality that is whizzing past in a blurred superposition. Armed with knowledge of how the qubit sees the world, you can then determine the mathematical transformation to perform on the particle to recover the information in the original qubit.

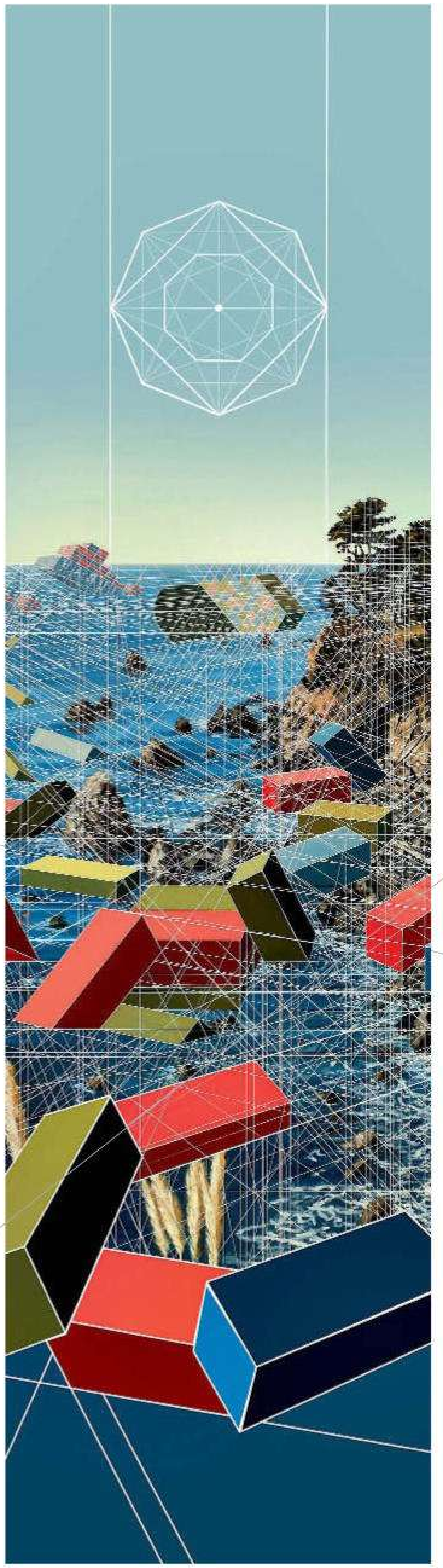
travel through two slits in a grating at once. "We see that, relative to the electron, it is the slits themselves that are in a superposition," says Pienaar. "To me, that's just wonderful." While that might all sound like mere theorising, one thing that gives Brukner's ideas credence is that they have already helped solve an intractable problem relating to quantum communication (see "Flying qubits", left).

Quantum reference frames do have an Achilles' heel though, albeit one that might ultimately point us to a deeper appreciation of reality. It comes in the form of "Wigner's friend", a thought experiment dreamed up in the 1950s by physicist Eugene Wigner. It adds a mind-bending twist to Schrödinger's puzzle.

Faced with the usual set-up, Wigner's friend opens the box and finds, say, that the cat is alive. But what if Wigner himself stands outside the lab door? In his reference frame, the cat is still in a superposition of alive and dead, only now it is entangled with the friend, who is in a superposition of having-seen-an-alive-cat and having-seen-a-dead-cat. Wigner's description of the cat and the friend's description of it are mutually exclusive, but according to quantum theory they are both right. It is a deep paradox that seems to reveal a splintered reality.

Brukner's rules are no help here. We can't hop from one side of the Heisenberg cut to the other because the two people are using different cuts. The friend has the cut between herself and the box; Wigner has it between himself and the lab. They aren't staring at each other from across the classical-quantum divide. They aren't looking at one another at all. "My colleagues and I were hoping that the Wigner's friend situation could be rephrased in quantum reference frames," says Brukner.

> "Alice and Bob's communication may forge the structure of space-time"



But so far, that hasn't been possible. "I don't know," he sighs. "There's a missing element."

Hints as to what that might be are coming from work by Flavio Mercati at the University of Burgos in Spain and Giovanni Amelino-Camelia at the University of Naples Federico II in Italy. Their research seems to suggest that by exchanging quantum information, observers can create a shared reality, even if it isn't there from the start.

The duo were inspired by research carried out in 2016 by Markus Müller and Philipp Höhn, both then at the Perimeter Institute in Waterloo, Canada, who imagined a scenario in which two people, Alice and Bob, send each other quantum particles in a particular state of "spin". Spin is a quantum property that can be likened to an arrow that can point up or down along each of the three spatial axes. Alice sends Bob a particle and Bob has to figure out its spin; then Bob prepares a new particle with the same spin and sends it back to Alice, who confirms that he got it right. The twist is that Alice and Bob don't know the relative orientation of their reference frames: one's x-axis could be the other's y-axis.

If Alice sends Bob just one particle, he will never be able to decode the spin. Sometimes in physics, two variables are connected in such a way that if you measure one precisely, the other no longer exists in a definite state. This tricky problem, known as the Heisenberg uncertainty principle, applies to particles' spin along different axes. So if Bob wants to measure spin along what he thinks is Alice's x-axis, he has to take a wild guess as to which axis that really is – if he is wrong, he erases all the information. The pair can get around this, however, if they exchange lots of particles. Alice can tell Bob, "I'm sending you 100 particles that are all spin 'up' along the x-axis." As Bob measures more and more of them, he can begin to work out the relative orientation of their reference frames.

Here is where it gets interesting. Müller and Höhn realised that, in doing all this, Alice and Bob automatically derive the equations that enable you to translate the view from one perspective to another in Einstein's special relativity. We tend to think of space-time as the pre-existing structure through which observers communicate. But Müller and Höhn flipped the story. Start

SUHAIMI ABDULLAH/GETTY IMAGES

with observers sending messages, and you can derive space-time.

For Mercati and Amelino-Camelia, who first came across the work a few years ago, that flip was a light-bulb moment. It raised a key question that turns out to have a crucial bearing on Brukner's work: are Alice and Bob learning about a pre-existing space-time or is the space-time emerging as they communicate?

Make some space

There are two ways in which the latter could play out. The first has to do with the trade-off in quantum mechanics between information and energy. "To gain information about a quantum system you have to pay energy," says Mercati. Every time Bob chooses the correct axis, he loses a bit of energy; when he chooses wrong and erases Alice's information, he gains some. Because the curvature of space-time depends on the energy present, when Bob measures his relative orientation he also ends up changing the orientation a tiny bit.

There could be a more profound sense in which quantum communication creates space-time. This comes into play if space is what's called "non-commutative". If you want to arrive at a point on a normal map, it doesn't matter in which order you specify the coordinates. You can go over five and up two; or up two and over five – either way you will land on the same spot. But if the laws of quantum mechanics apply to space-time itself, this might not be true. In the same way that knowing a particle's position prevents you from measuring its momentum, going over five might prevent you from going up two.

Mercati and Amelino-Camelia say that if space-time does work in this way, Alice and Bob's attempts to find out their relative orientation wouldn't merely uncover the structure of space-time, they would actively forge it. The choices they make as to which axes to measure would alter the very thing their communication was meant to reveal. The pair have also devised a way to test whether this is really the case (see "Does space-time commute?", left).

All this work points towards a startling conclusion: that as people exchange quantum information, they are collaborating to construct their mutual reality. It means that if we simply look at space and time from one perspective, not only do we miss its full beauty, but there might not be any deeper shared reality. For Mercati and Amelino-Camelia, one observer does not a space-time make.

That leads us back to the Wigner's friend paradox that flummoxed Brukner. In his work, observers can be treated as having perspectives on the same reality only when they are gazing at one another from across the Heisenberg cut. Or, put another way, only when it is possible for them to communicate, which is precisely what Wigner and his friend can't do. Perhaps this is telling us that until two people interact, they don't share the same reality – because it is communication itself that creates it.

Amanda Gefter is a science writer based in Massachusetts. She is the author of *Trespassing on Einstein's Lawn*

Does space-time commute?

In ordinary space, it isn't the journey that matters so much as the destination. If you're trying to arrive at a given place, it makes no difference whether you head 5 kilometres south and then 3 kilometres west, or vice-versa. That is because the coordinates "commute"; they get you to the same spot regardless of the order.

At very small scales to which quantum theory applies, this might not be true. In quantum theory, measuring a particle's position erases information about its momentum. Similarly, it could be that the order in which movements are made could affect the structure of space. If this is so, it makes no sense to talk about space-time as a fixed arena.

Physicists Flavio Mercati and Giovanni Amelino-Camelia think they have a way to find out whether space-time commutes. They were inspired by research that imagined two people exchanging quantum particles and measuring their properties to deduce their relative orientation (see main story). What would happen, Mercati and Amelino-Camelia asked, if this game were played for real?

As the people exchange more and more particles, their uncertainty about their orientation should decrease. But will it ever get to zero? In ordinary space-time, it will. But if space-time is non-commutative, some uncertainty will always remain, since their orientation is ever so slightly rewritten with each measurement. The pair might have to exchange trillions of particles before we will have an answer – but Mercati thinks it is worth a try.

JENNIE EDWARDS

"Many people's understanding of geology is through the colonial lens of resource piracy"

Christopher Jackson thinks geologists like himself have a reputation for ravaging the natural world. He's out to make amends, he tells Abigail Beall

Want more from Christopher Jackson?
Hear him speak at New Scientist Live next month
newscientistlive.com

FROM the breathtaking Atlas mountains in Morocco to the expansive deserts of the US, Christopher Jackson's work has taken him to some incredible places. Incredible and sometimes risky, too: he has been held at gunpoint and put in prison in the line of duty. Why does he do it? Just for the sake of a few old rocks.

Geologists might have a long list of adventure stories to recite and an enviable set of stamps in their passports, but Jackson says that in many people's eyes, they don't have a good reputation. After all, they often use their knowledge of Earth's rocks and tectonic processes to identify rich mineral seams to dig up and fossil fuels to drill, all of which is a horror to the environment.

Now, Jackson is seeking to flip the story. As chair in sustainable geoscience at the University of Manchester, UK, he says geologists must play a crucial part in fighting climate change. That means helping to create technologies that allow us to live more sustainably and spreading the word about our planet's climate history. Earth's rocks were formed at various points in the past, and their chemistry and structure reflect the conditions that prevailed at the time. This geological record can be read to reveal how our planet's climate has warmed and cooled over the aeons – a story that can help us better understand climate change in our own time. Jackson spoke to *New Scientist* about his epic travels, how geology can help us live with less environmental impact and the difficult task of improving diversity in geosciences.

Abigail Beall: Your job has taken you to lots of exciting places. Do you have a favourite?
Christopher Jackson: As a geologist, you go places that few others ever get to visit because you're interested in rare, weird rocks and those tend to be in far-flung places. That's always a tingle.

The Atlas mountains were pretty spectacular. I went there to study the way rock salt deforms to generate giant structures within the Earth's crust. You drive across these desert plains for several hours and you eventually start to wind up in mountains, at really high elevations. You go from desert to forested areas to then bare rocks. It's remote and beautiful country with beautiful people living there.

I imagine it can be dangerous at times.
My colleagues and I have had guns pointed at us in Egypt. We were arrested there and had our passports confiscated. In Argentina a few years ago, we got arrested and put in a prison in a cell overnight. I've had racist abuse in the US while doing fieldwork at the Colorado-Utah border. Sometimes, people can be suspicious of geologists on their land, even though you have the right permissions to be there.

A lot of this work is to understand Earth's past climate. Why is that so important?
The trouble is that in some people's minds, it's cold at the North and South Pole and it's very hot in the deserts, yet people have managed to survive in all those places. So what harm can a few degrees of global warming do?

The information we can gather from layers of rocks built up in Earth's surface over millennia can answer that question. It tells us how the changing climate impacted the existence of living creatures on Earth.

> "We need to be aware of geological history and how it could replay in our time"

JOHANN RAGNARSSON/ALAMY

As selfish beings, that's what we're concerned about, right?

The rock record tells us that abrupt, large swings in climate, such as we're presently seeing, can lead to the dramatic loss of life. Looking back into the geological record gives us a baseline to understand what we're living through now and what we might live through in the future.

How can rocks tell us about the effects that past changes to the climate had on life?
The first job is to understand what the climate was like in the past, and for that we need to use proxies, signals in ancient rocks that vary in ways that were affected by things like temperature or rainfall. We commonly analyse the chemical composition of very small marine fossils called foraminifera in the rocks. Sometimes the composition and texture of the rocks themselves record climatically driven events such as sea level rise. The other thing we do is use the fossil record to look at extinctions. Then we can compare the two timelines and see correlations between changes in temperature, say, and what happened to Earth's biodiversity.

What sorts of things do we learn from those timelines?
One interesting point is how things living

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Geologists often help find oilfields (below). They can also locate sites for geothermal power stations, like this one near Reykjavik, Iceland (left)

on land and in the seas were affected differently by climate change in the past, with life in the ocean often getting hit harder. The air getting hotter is one thing, but that also leads to oceans becoming more acidic and that is another thing entirely for the animals that live in the marine realm. We humans are land-dwelling creatures, but we rely on the oceans for food and energy, so we need to be aware of this geological history and how it could replay in our time.

Why do you feel that geologists don't have the best reputation?

Geology is naturally a global subject: the processes are not limited by country borders. But a lot of people's understanding of geology is through a colonial lens of resource piracy: "I know there's a mine here and I know this mine basically killed a bunch of people" or "there's an oil field and people make a load of money and they come down in fancy cars, while we don't have any food".

In other words, many people's understanding of geology is a net negative one, and I understand why. We're going to have to learn from the past. My plan, as chair in sustainable geoscience, is to continue to make the public and government aware of the key role geoscience plays, and will continue to play, in tackling the climate crisis.

How can geology help fight climate change?

Geology is going to be fundamental to developing low-carbon economies. If we are to have more energy sources that are not based on fossil fuels, we need geologists to help locate and develop geothermal and hydrothermal resources for power, for instance. Geologists are trained to visualise and model heat transfer and fluid flow in the Earth's subsurface. This is critical to understanding which rocks and locations might be most productive in terms of hydrothermal energy, and for drilling wells that help optimise the use of this resource.

Exploring the rocks of the UK, the stuff right beneath our feet, is really exciting. It turns out we have fantastic geology suitable for geothermal heat extraction in Cornwall, for example.

We also need geologists to contribute to carbon capture and storage. They have the skills to locate rocks and structures that may trap carbon dioxide securely for hundreds of thousands to millions of years. They are trained to use borehole data and geophysical scans of the Earth's subsurface to build up an understanding of the distribution of different rock types. This kind of analysis is teaching us that the Irish Sea and the North Sea are locations where the geology is appropriate for CO_2 storage.

By the way, geoscience is also really important for helping us achieve many of the UN Sustainable Development Goals, the internationally agreed targets for improving people's standard of living around the world. Some of the most important goals include giving people access to energy and water. Geology has been, and will continue to be, crucial for locating these resources.

Earlier this year, you were a co-author of a paper about the racial diversity crisis in geosciences in the UK. What did you find out?

It was a study of racial and ethnic diversity in UK geosciences higher education. The results were totally depressing, but not surprising. We saw there's a gross under-representation of Black, Asian and minority ethnic students in undergraduate geosciences, and we see the same pattern for postgraduate geoscience studies as well. Roughly 19 per cent of 18 to 25-year-olds in the UK population come from a Black or ethnic minority background. But if you look at people of those ages studying science generally, it's only around 17 per cent, so a slight under-representation. Our study found that in geology, it is substantially smaller again, at only 10 per cent.

Have you seen any changes in this respect since the start of your career?

Not in terms of statistics, but I have seen an increase in the willingness to discuss and address the underlying issues. This gives me hope for the future. But it takes a huge amount of effort, and it takes away from the thing you want to do, which is science.

Not many people grow up saying: "You know what? I want to spend a lot of time discussing these really emotionally challenging things, which are upsetting to talk about and might not lead to change." We're drawn into that fight to help more junior people. It is a difficult space to navigate, and it will never make you popular. But I don't particularly care about that. ▮

Abigail Beall is a feature editor at *New Scientist*

BRETT RYDER

Feel the beat

Our inability to tap into our body's inner signals has been implicated in poor mental health – but there are ways to get back on track, finds **Caroline Williams**

LYING in the dark, my senses are straining for inputs and finding none. I am floating in warm, salty water that is so close to my body temperature, I can't tell where my body ends and the water begins. After a while, my senses go quiet and my focus turns inwards. Now, all I am aware of is my breathing and the surprisingly loud beating of my heart.

I am inside a pod-like floatation tank to try to boost my powers of interoception. According to a growing body of research, interoceptive sensations – those that originate from within the body, from its tissues, organs and chemicals circulating in the bloodstream – hold the key not only to better mental well-being, but to revolutionary new treatments for common, yet hard-to-treat conditions like depression, anxiety and eating disorders. With several now in clinical trials, it is a change of direction that could see the focus on the brain alone in mental health become a thing of the past, offering hope of progress for millions.

In recent years, it has become clear that to really understand mental health, you need to factor in just how much the brain cares about what is going on below the neck. For any animal, survival depends on how well it can detect physical changes that may signal a threat and to take appropriate action to get things back on track. Interoception is a bit like our sixth sense – the ability to detect these bodily changes, from heartbeat to changing concentrations of certain hormones in the blood, as well as the psychological expression of these as feelings and emotions. Integrated by the brain, these changing bodily sensations feed into our mental state and behaviour, consciously or unconsciously, and have a say in every thought and emotion we have. "Interoception is fundamental to every brain process and behaviour that there is," says Hugo Critchley, a neuroscientist at the University of Sussex, UK, who studies the process.

Under the radar

The reason that we generally aren't cognisant of this life-sustaining system is because interoceptive messages are below the radar of conscious awareness most of the time. They can and do break the surface when something needs to be addressed, motivating us to seek out food when our stomach rumbles, or get ready to run when we feel a rush of adrenaline.

Yet even when they are being detected at the unconscious level, these signals can affect the way we think, feel and behave. Some scientists believe that the brain's integration and interpretation of them is what provides the sense of self, that there is one "I" living in this moment and experiencing the world in real time, and that any change from the status quo has an important impact on whether that experience feels good or bad. This makes it particularly relevant to mental health. If feelings and emotions are built on bodily sensations, perhaps errant bodily signals, or the brain's interpretation of them, are feeding into feelings of emotional distress.

The challenge to unravelling all this is that the brain-body pathways involved are fiendishly complicated. The body is crammed full of sensors, not to mention kilometres of nervous pathways connecting the organs to each other and the brain. Body and brain communicate in both directions, each responding to the other and tweaking things as necessary. This cacophony is broadcast over a huge range of timescales, from the rhythmic beating of the heart over seconds to changes in hormones and other chemicals in the bloodstream over minutes or hours.

To make sense of all this information, the brain employs a certain amount of guesswork, taking mental shortcuts based on past experiences. This predictive processing is a leading explanation for how the brain works in general: it involves making a best guess based on what happened on prior occasions, comparing that prediction with incoming information from the senses and intervening if there is a mismatch between the two.

Where this becomes relevant to mental health is that people vary considerably, not only in the predictions their brains make, but also in their physiological sensitivity to bodily changes and in the threshold at which unconscious signals cross over into conscious awareness. The way people respond to these signals and the meaning they attach to them plays out in many mental health conditions.

Take, for instance, anorexia, which has the highest death rate of all mental health conditions and is notoriously difficult to treat. One aspect that is particularly hard to address is the intense and unpleasant sensations of having food in the gut after eating. "I'd be so aware of the food inside of me that it would be hard to walk... How could I move with all of this in me?" says Susan Burton, who wrote *Empty: A memoir* about her experiences of anorexia.

Sahib Khalsa, a psychiatrist at the Laureate Institute for Brain Research in Tulsa, Oklahoma, was intrigued by an anorexia patient who had told him that spending time in a floatation tank made this uncomfortable sensation go away. "She felt that was the only place that she could digest in comfort," says Khalsa. ›

> **“Interoception is fundamental to every brain process and behaviour that there is”**

This makes sense because floatation therapy can help to selectively remove certain interoceptive inputs. So Khalsa decided to investigate the idea further as a therapy for people diagnosed with anorexia.

In a study last year, Khalsa found that after four weekly sessions in a floatation tank, interoceptive messages from the gut were reduced. “People feel their heartbeat and their breath more intensely when they float, but don’t feel their stomach more intensely,” he says. Participants also reported reduced anxiety and body dissatisfaction ratings after floating, although the effects didn’t last long.

Oversensitivity to bodily signals can also be an issue in generalised anxiety disorder, a condition that is linked to uncontrolled worrying and an almost constant underlying sense of dread. To get a better insight into this condition, Khalsa injected volunteers who had generalised anxiety with isoproterenol, a drug that acts like adrenaline, but doesn’t cross the blood-brain barrier. This means any changes in emotional state invoked by the substance could be attributed to bodily sensations rather than a direct effect on brain chemistry.

Sensitive to threats

He found that the dose of isoproterenol needed to raise heart rate and anxiety was significantly lower in people with generalised anxiety disorder than in a control group, suggesting that their bodies are set up in such a way that they ramp up the fight-or-flight response at a much lower level of perceived threat.

Once the fight-or-flight response is under way, the very fact of having a raised heart rate then primes the brain to be more sensitive to threat, setting up a vicious cycle of overactive bodily signalling and negative interpretation that boosts interoceptive sensitivity. In experiments, Critchley and Sarah Garfinkel, then also at the University of Sussex, found that fearful images shown as the heart contracted were rated as more intense than if the same images were shown as the heart relaxed. This suggests that a racing heart could make a bad situation worse. “Just being in that constantly aroused state means that fear processing and fear memories are augmented,” says Garfinkel, now at University College London.

One potential way to break this cycle is to short-circuit the link between the cardiovascular system and fear processing in the brain, an idea that is being tested in people with post-traumatic stress disorder (PTSD), where an overactive fight-or-flight response leads to a racing heart, fast breathing and other debilitating panic-related symptoms in situations that are, objectively, safe. A clinical trial of a blood pressure-reducing drug, losartan, as a treatment for PTSD is under way in hospitals across the US. The idea is that by reducing the cardiovascular overreaction, people with PTSD stand a better chance of being able to calm down before the vicious cycle gets out of control.

Another potential approach is to help people to learn how to reinterpret their body sensations, giving them a better chance of regulating their emotions.

TUNE IN TO YOUR BODY

There are ways we can all hone our interoceptive senses:

MEDITATE: Styles of meditation, such as mindfulness, that encourage noticing bodily signals and then letting them go may counter the runaway body-mind pathways that can contribute to anxiety.

STIMULATE THE VAGUS NERVE: DIY ways to do this include breathing at the rate of six breaths per minute, splashing your face in cold water or shutting your eyes and extremely gently pressing on your eyeballs.

GET MOVING: Sedentary lifestyles leave us out of touch with our bodily signals. Raising your heart and breathing rate via exercise may help increase sensitivity in a controlled way and help to better put them in context.

FLOAT: Floatation tanks take away external sensory information and help you tune in to your heartbeat and breathing. It may also reduce gut discomfort in eating disorders (see main story).

Research has shown that problems with interoception often arise not only when a person has inaccurate body signals, but when this is combined with a negative interpretation of what those signals mean. In anxiety in particular, the combination of being worse at accurately tuning into body signals, combined with a propensity to expect bad things to happen, is especially problematic, again setting off a vicious cycle.

Critchley wanted to find out whether addressing this would help reduce anxiety in autistic people. They experience anxiety at up to five times the rate of the general population and cognitive or group therapies often aren’t suitable for them.

In a clinical trial of more than 100 autistic people, participants were trained to better tune in to their heartbeat, either by counting the beat or by trying to work out if an audible beep was in sync with their heart. The training also involved light exercise, to raise the heartbeat and give them practice of detecting it in non-threatening situations.

“They could get into the zone where they could feel their heartbeat and then gradually relax and still feel their heartbeat while tuned into it,” says Critchley.

Increasing awareness of heartbeat seemed to be enough to short-circuit rising anxiety. Participants reported a significant drop in anxiety scores over three months, and around a third no longer qualified as having a clinical anxiety disorder. Interoceptive heartbeat signals were rated as less intrusive, and people reported being better able to put the sensation into context. “When I notice the impacts of anxiety on my body, I am more aware of them and am able to reassure myself that it is just a physical reaction. I am better at taking deep breaths and trying to slow my breathing and heart rate down,” said one participant.

With these early promising results, the hope is that the training can be extended to other conditions. It could be used to tackle emotional overeating, for example, which has also been linked to problems with interoception.

Another group who could benefit are people with hypermobile joints – ones that extend beyond the usual range of motion. This affects as many as 1 in 5 people, and anxiety and panic disorders are significantly more common in this group. There are also links with chronic pain, fatigue and eating disorders.

The extreme bendiness of the joints is caused by a more flexible form of collagen, but collagen is also found in blood vessels. Laxer collagen here causes blood to pool in the lower legs, which forces the heart to beat faster to maintain blood pressure. This racing heart can be interpreted as anxiety, even when there is no obvious cause for concern. Jessica Eccles, also at the University of Sussex, is now investigating if training people to interpret these signals differently may bring some relief.

More direct ways to calm the body are also being developed. The descending branch of the vagus nerve is part of the parasympathetic nervous system, which returns the body's arousal back to a calm baseline after stress. Electrically stimulating the vagus nerve via an implant in the neck has been shown to reduce symptoms of anxiety and depression in people with a clinical diagnosis of these conditions. Non-invasive ways to stimulate the nerve are now in the works, although there is little hard evidence so far that this non-implanted method works for mental health conditions.

SPIDEY SENSES

Counter-intuitively, it seems to be possible to use the fear-boosting effects of a rapid heartbeat (see main story) to help tackle severe phobias. These are often treated with exposure therapy, in which a person is gradually confronted with a more intense version of their greatest fear while they learn that it is safe to experience it.

In one study, people with arachnophobia were shown images of spiders as their heart contracted. They became able to tolerate spiders sooner than those who were shown an image that was timed with the relaxation of the heart. Showing people spiders when their fear system was most heightened, but in a controlled setting, seemed to supercharge the exposure therapy, allowing them to recover emotional control more quickly.

A deeper understanding of the complexities of interoception will also help to inform future treatments. Khalsa is working on a way to explore gut sensitivity in eating disorders and how it manifests in the brain. He has designed a vibrating capsule that can be swallowed and used as a probe to measure gut sensitivity. Combined with electroencephalography, which measures brain activity using sensors on the scalp, this will allow mapping of possible differences in the brain's response to gut sensation.

A test on 40 healthy volunteers has so far shown that their perception of the probe grew as the intensity of vibrations increased, which correlated with increased activity in parts of the brain that are thought to be a gastric detection network. Khalsa is working on a trial in people who are hospitalised with anorexia to see if differences in their gut sensitivity predict their chances of recovery over the long term. The ultimate end point would be a way to intervene in this process to improve chances of recovery.

Khalsa hopes that we will eventually understand interoception so well that we can "go through the process stepwise, identifying where in the nervous system is the issue", he says. When it is easier to identify where problems arise, new targets for treatments will follow. And with more knowledge of how to intervene for ourselves comes the possibility of using forms of self-care that improve our mental health – whether that is a session in a floatation tank or doing star jumps to get used to how your heart feels when it is pumping hard and how to use deep breaths to calm it down afterwards.

While it is early days for evidence-based interoceptive treatments, Garfinkel believes that the time for ignoring the body's role in mental health is well and truly over. "Mental health conditions, especially those with some degree of emotional disturbance, have their origin in aberrant interoceptive mechanisms and any treatment that targets the body has the potential to help treat these conditions. I honestly believe it's a potential revolution in mental health treatments," she says. ▮

Floatation therapy can help to quieten certain body signals

REUTERS/FRANCIS MASCARENHAS VIA ALAMY

Caroline Williams is a science journalist and the author of *Move! The new science of body over mind.*

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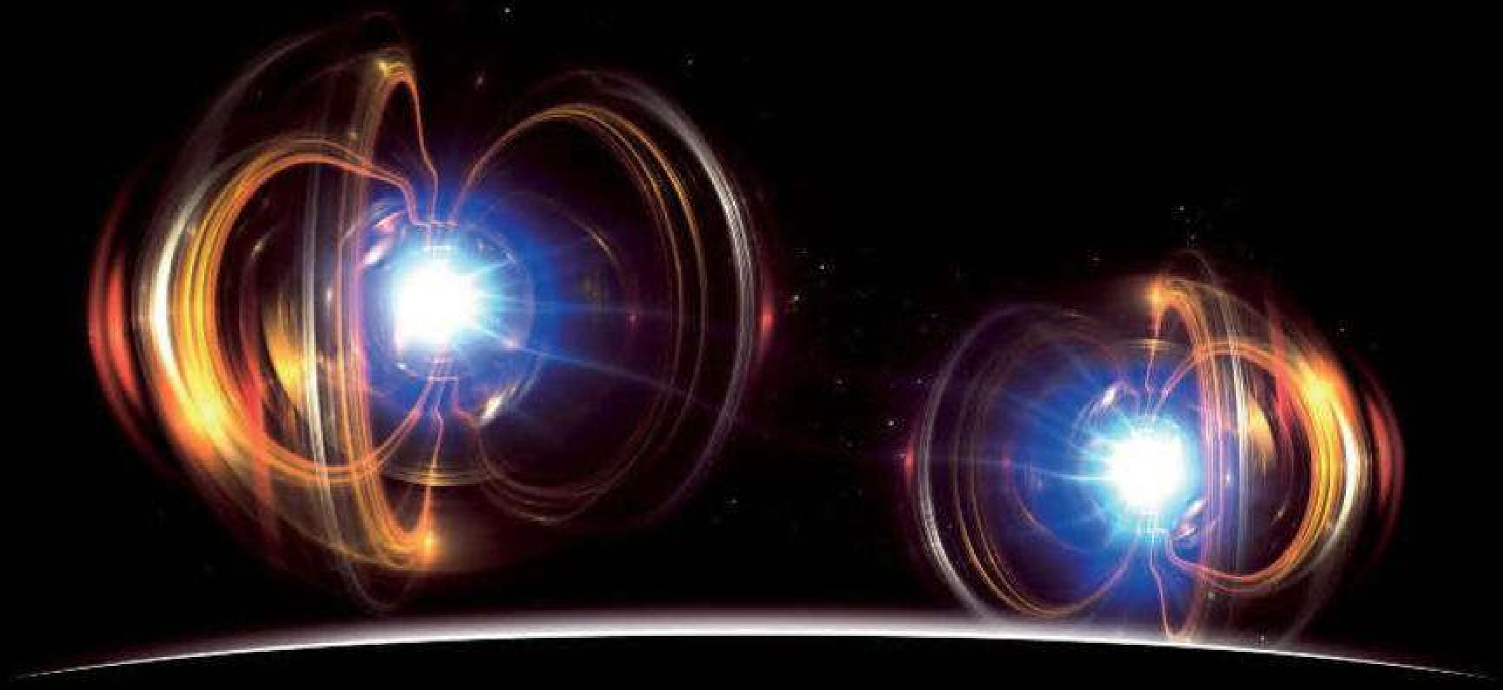

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Science of gardening

A cloche of ideas

Temperature swings can prove challenging to young plants, says **Clare Wilson**, who offers some simple solutions

Clare Wilson is a reporter at *New Scientist* and writes about everything life-science related. Her favourite place is her allotment @ClareWilsonMed

What you need

Sweet pea seeds
Large plastic soft-drink bottles
Bamboo canes

Science of gardening appears every four weeks

Next week

Citizen science

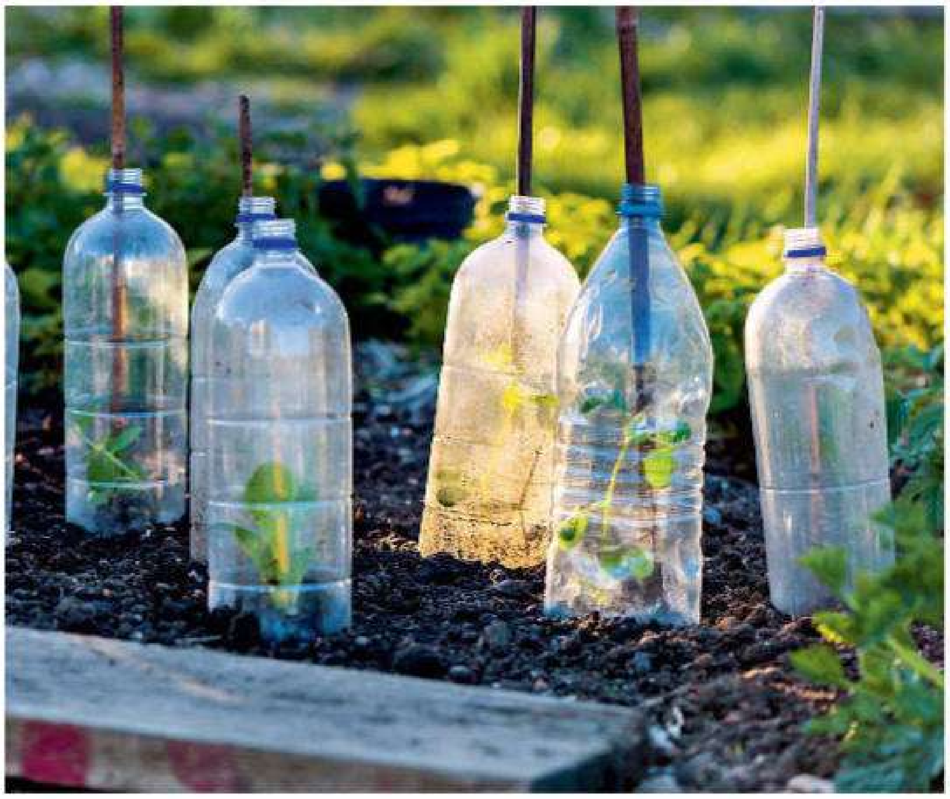
IN MY garden, bulbs such as snowdrops are coming up. Every year, I wonder if spring is arriving earlier due to climate change.

One study from 2006 found that many signs of spring, such as plant species unfurling their leaves, had been hastened by 7.5 days across Europe in the previous 30 years (*Global Change Biology*, doi.org/b7vmgk). And research published this week has found that UK plants are flowering nearly a month earlier than they did before the mid-1980s, probably due to warmer temperatures from January to April (see page 7).

You might think that warmer weather would be welcomed by gardeners, but some plants, particularly fruit trees and bushes, require a period of cold before they break their winter dormancy, so warmer winters could lead to worse crops. In the UK, blackcurrant bushes may be especially vulnerable, although new varieties are being bred to tolerate a warmer climate.

Early springs are good for many crops, as they extend the growing season, letting you sow seeds and plant seedlings earlier. But gardeners need to beware of late frosts, when an unexpected cold spell means temperatures overnight fall below freezing, which can blacken foliage and kill off tender plants.

After a few disasters, including a year when I lost my entire crop of new potatoes, I now keep a close eye on the weather forecast. If plants look in danger, they can be protected by overlaying them with a thin sheet of fabric called horticultural fleece. In a pinch, old sheets or net curtains will suffice.



GAP PHOTOS/ANNA OMIOTEK-TOTT

Another option to protect new seedlings is a cloche, a transparent dome that creates a miniature greenhouse around a young plant. You can buy them or make your own by cutting large soft-drink bottles in half and pushing each dome firmly into the soil. "You're bringing a plant on by changing its microclimate to a warmer one, so it will grow and develop faster," says Tim Sparks at the University of Cambridge, who was involved in both the 2006 study and the new flowering research.

If using cloches, you must keep a close eye on the weather, as a sunny spell could mean young plants overheat and dry out to a husk. But if you use the top half of a bottle, you can put the cap on and off to ventilate or keep heat in as needed, without disturbing the plant.

I use these cloches for seedlings of peas, beans and ornamental sweet peas, among other things. Depending on where you live, you may soon be able to start sowing sweet peas indoors in small modules for planting into the ground or large pots outdoors later, under bottle cloches. When the weather gets warm enough, or the plants too big, remove the cloches and stick bamboo canes into the soil for the plants to climb, helped by regular tying in. Three canes lashed together make a sturdy tripod structure. ▮

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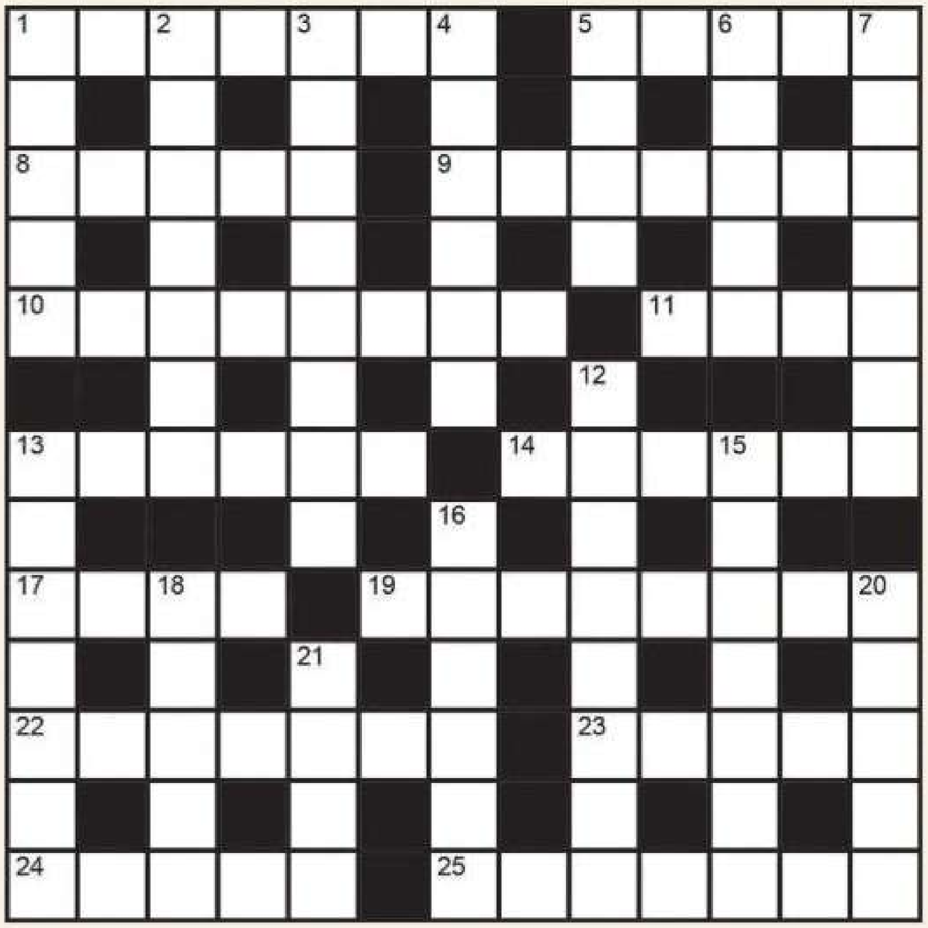
Cryptic crossword #76 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Online nuisance manipulated top MBAs (7)
5 Those things retaining right amount of heat (5)
8 Acquired relative importance now leader's away weekly, for starters (2-3)
9 Repeatedly hits all-you-can-eat spreads (7)
10 Powerful engine I heard in France, feeding flatfish (8)
11 Bluish-green tin punctured by fork (4)
13 With husband gone, complained like a gadfly (6)
14 Bitter shot in wake of victory (6)
17 Bring back tabletop game circuit (4)
19 Fresh peony kept in very attractive jar for Pooh Bear (8)
22 Reform in CIA includes outwardly senseless probe (7)
23 Embellish commotion at centre of learning (5)
24 Herb is in test facility after a turn (5)
25 Obliterate former Porifera member, reportedly (7)

DOWN

1 Sieve traps white bird (5)
2 Prison guard doffing cap aboard section of plane (7)
3 Hugely impress fan of gift decoration? (4,4)
4 Battle refurbished digital device (6)
5 Flipped saucer, say, under bit of tasty protein (4)
6 Gritty material in brain stem erythrocytes (5)
7 Stonework child owned by palaeontologist Anning (7)
12 Tip me off about conflict happening near a black hole? (4,4)
13 Blow-up involves football club beginning to unleash wild youngster (4,3)
15 Photon scattering surrounds variable weather event (7)
16 Pliant coiled plastic (6)
18 Band's disc coming with sales warning (5)
20 For example, present simple contract (5)
21 Through with large bottle (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #137

1 How many extant species of wombat are there?

2 What is the tallest uninterrupted waterfall in the world, excluding underwater falls?

3 The four nucleobases found in RNA are adenine, cytosine, guanine and what else?

4 In astronomy, what is an alignment of three or more celestial bodies called?

5 What is the highest-amplitude type of brainwave?

Answers on page 55

Puzzle

set by Rob Eastaway

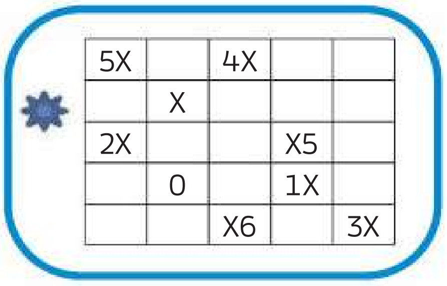
#153 Tightwad's safe

Tom Tightwad keeps his money in a safe, the code for which is a 10-digit number that uses every digit between 0 and 9.

Fearful of forgetting the code, Tom wrote it on the front of the safe, but disguised it. He wrote the first five digits along the top of a 5x5 grid, and the last five digits down the side. Then he multiplied each digit along the top by each digit down the side, filling the grid with 25 numbers. Finally, he erased his code number from the top and side so that only the grid remained.

Unfortunately, the clumsy fellow also erased most of the numbers in the grid. And of what remains, some digits are so hard to read that they have been replaced with an "X" (for example, in the diagram, the code's first digit multiplied by its eighth digit is now "20-something").

Can you crack the safe?



5X		4X		
	X			
2X			X5	
	0		1X	
		X6		3X

Solution next week

Best friends?

Are pet dogs just suffering from Stockholm syndrome, or do they genuinely enjoy our company?

Clive Wynne
Department of Psychology, Arizona State University, US
Author of Dog is Love

It's true, our dogs are trapped with us, not allowed to leave the house unless tethered to a human on a leash and, yes, fully dependent on us for everything they need in life – and yet their love for us transcends anything like Stockholm syndrome.

I see this most obviously when I return home from a walk with my dog, Xephos. Her joy at seeing my wife and son transcends how a kidnapped person would respond to being returned to their jailers.

This is also clear when we consider that the majority of the world's 800 million dogs don't live as pets, captive inside a house. Most roam the streets of poorer countries. These aren't anyone's captives and yet they still form emotional bonds with individual people. Studies by Anindita Bhadra at the Indian Institute of Science and Education in Kolkata, India, and her colleagues show that street dogs rapidly form affectionate ties with people who treat them gently. Light petting builds a bond of trust faster even than offering pieces of chicken.

> **"My dog's joy at seeing my family transcends how a kidnapped person would respond to being returned to their jailers"**

There is considerable value in being clear-eyed about the way we constrain our dogs' lives, but that doesn't mean that their love for us amounts to Stockholm syndrome.

Joe Sweeney
via Twitter

Not sure about dogs, but with cats, it's the other way around.

Why is more smoke produced when you have just blown out a candle?

DEEPOL BY PLAINPICTURE

This week's new questions

Burn out **Why does a candle make more smoke just after it has been extinguished?** ***Bob Yelland**, Alton, Hampshire, UK*

Fungal friends **Plants and fungi share highly developed symbiotic relationships, but do humans, or any other animal, enjoy similar beneficial relationships? Or is it all just itchy feet and flaky skin?** ***David Pidgeon**, Bristol, UK*

Solar vibe

My yoga teacher is hosting a gong bath where the gong is supposedly tuned to the frequency of the solar system. Does the solar system have a frequency? If so, is it possible to tune a gong to it?

Garry Trethewey
Cherryville, South Australia

The word "frequency" alludes to how frequently something recurs. As an exercise, we could look at just some of the frequencies that the solar system can display.

The sun emits electromagnetic radiation with frequencies from 10^{18} hertz (1 million million million waves per second) down to a sedate 10^4 hertz (10,000 waves per second). The sun spins on its axis about every 27 days. Mercury orbits the sun in 88 days, and Neptune does so in 165 years. The whole solar system orbits the centre of the galaxy in about 230 million years.

Whatever gong your yoga teacher chooses, there will certainly be some frequency that it is tuned to.

Herman D'Hondt
Sydney, Australia

This claim can be debunked for a number of reasons. The solar system has an enormous number of different frequencies. It just depends on what you look at. For example, Earth turns once every 24 hours ($f = 0.0000116$ hertz). Every other object in the solar system has it own frequencies. None of these is more important than any other, and together they would make quite a cacophony.

As well as this, a gong will vibrate at audible frequencies, i.e. somewhere between 20 and 20,000 Hz. Audible frequencies have to be generated by small objects; the larger the object, the lower its frequency will be. As we know, the solar system is huge, far too large to generate a frequency in the range of a gong. Even things like earthquakes have frequencies that are below the audible range. The planets' orbital frequencies would need to be multiplied by about 100 billion to bring them into the audible range.

Finally, sound is vibration, and the movements of solar system objects aren't. They are elliptical movements in a vacuum and have nothing to do with vibration.

Helen Harris
Edinburgh, UK

Sound therapists may use gongs described as being "tuned" to a particular celestial body in our solar system. The concept of the sun, the moon or a planet being associated with sound has its roots in the *musica universalis* ("music of the spheres"). This is a philosophical concept from ancient Greece, in particular Pythagoras and his followers.

They reasoned that just as the vibrations of the air resulting from a taut string being plucked produce sound, the sun, the moon and the planets all emit their own unique hum based on their orbital revolution.

Then, in the early 17th century, astronomer Johannes Kepler in his *Harmonices Mundi* ("harmony of the world") described the orbital motions of the sun, the moon, Earth, Mercury, Mars, Jupiter, Saturn and Venus (all the planets known at the time). He calculated that their motions nearly perfectly match musical intervals and harmonies. He believed that, while inaudible, these could be heard by the soul.

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Tom Gauld
for New Scientist

WHERE ARE YOU OFF TO, GARY?
SOME SCIENTISTS STUCK THIS TRACKER THINGIE ON ME, SO I'M SWIMMING TO BELGIUM, JUST TO MESS WITH THEM.
HA! CLASSIC GARY!

In the late 1970s, Hans Cousto, a Swiss mathematician and musicologist, described the natural law of the cosmic octave as the link between different kinds of periodically occurring natural phenomena, such as the orbit of the planets, the weather, colours, rhythms and tones. Using a formula he devised, Cousto transposed astronomical periods into audible frequencies.

As a result of a collaboration between Cousto, musician Jens Zygar and the gong manufacturer Paiste, a series of Planet Gongs were made in the 1980s based on Cousto's theory of the cosmic octave. The tuning relates to the fundamental note (the lowest and loudest-frequency note we hear) created by striking a particular gong. For example, the Paiste Venus Gong has a fundamental of A2 (i.e. pitch A in the second octave), while the Paiste Mars Gong has a fundamental of D2.

However, Planet Gongs are so rich in tones and overtones that when they are struck, they create such a continuum of sound that choosing a particular gong because of its fundamental may not be the best way for the listener to benefit from the wealth of vibrations being produced and picked up by the body physically as well as audibly.

> **"The concept of the sun, moon or a planet being associated with sound has roots in the *musica universalis* ('music of the spheres')"**

When to panic

We are often told that "now is not the time to panic" when a crisis is looming or happening. When is the right time to panic? (continued)

James Fradgley
Wimborne, Dorset, UK
I have noticed that different people have different panic reflexes. Some freeze, some run, etc. Mine is to carry on doing what I am doing. There does seem to be consistency of panic response in an individual. My conclusion is that these varied responses might enable some to survive.

Bob Denmark
Garstang, Lancashire, UK
If you panic and run away from a tiger (as previously discussed in your 4 December issue) with or without a broken leg, it will almost certainly chase you, catch you and, if it is hungry, eat you. Keeping still and maintaining eye contact is recommended by those who work with tigers in the wild. Thinking is usually better than panicking.

Steve Hyams
Prestwich, Greater Manchester, UK
Surely when the shit has hit the fan, it is already too late to panic, but before the shit has been despatched, it is too early. So somewhere between the two, depending on distance from source to fan and speed of travel, is about the right time to panic if you are quick. I seem to recall an equation for this and it is possibly the only use I have ever found for school algebra. ▮

Answers

Quick quiz #137
Answers

1 Three: the common wombat (*Vombatus ursinus*), northern hairy-nosed wombat (*Lasiorhinus krefftii*) and southern hairy-nosed wombat (*Lasiorhinus latifrons*)
2 Angel Falls in Venezuela
3 Uracil
4 A syzygy
5 Delta waves, frequency 1-3 Hertz

Quick Crossword #100 *Answers*

ACROSS 1 Cramp, **4** Silica gel, **9** Dioxide, **10** Walkman, **11** Imago, **13** Lilac, **15** Lux, **16** Fly, **17** Brass, **19** Brain, **21** Yeast, **23** Loris, **24** Dow, **25** WMD, **26** Boyle, **28** Cilia, **29** Rhodium, **31** Taproot, **33** Dodgem car, **34** Sedge

DOWN 1 Caddis fly, **2** Apogamy, **3** Phi, **4** Steel, **5** Low, **6** Colic, **7** Gemella, **8** Linux, **12** Orbit, **14** Laser, **18** Alloy, **19** Basic, **20** Newcastle, **22** Android, **24** Deltoid, **25** Wired, **26** Brine, **27** Ester, **30** Mac, **32** Pus

#152 Lightning strike
Solution

Call the time of the first strike T1. After that, the clock reverses, and 30 minutes later the clock is 1 hour behind real time. Another lightning strike now makes the clock reverse again, going forwards but 1 hour behind. Thirty minutes later (at T2), the third strike reverses the clock again. The times on the bedside clock and my watch coincide at 7 o'clock, so T2 must be 1.30am (when the bedside clock was an hour behind). T2 was two strikes (1 hour) after T1, so the first strike was at 12.30am.

Va va vacuum

Like many people who have difficulty distinguishing science fact from fiction, Feedback is anticipating with trepidation the rise of the sentient machines. We see the story recently reported by the BBC, "Robot vacuum cleaner escapes from Cambridge Travelodge", as a kind of low-budget prequel.

"The automated cleaner failed to stop at the front door of the hotel in Orchard Park in Cambridge on Thursday, and was still on the loose the following day," the article informs us, emphasising the point made by observers, sensibly hiding on social media, that robotic vacuum cleaners have no natural predators in the wild.

Nature also abhors a vacuum, of course. Fortunately, the Cambridge incident had a happy ending: the errant sweeper was "found under a hedge on Friday". A mere test run, we fear. As is traditional, we would like to take this opportunity to state that we, for one, welcome our new robot vacuum cleaner overlords.

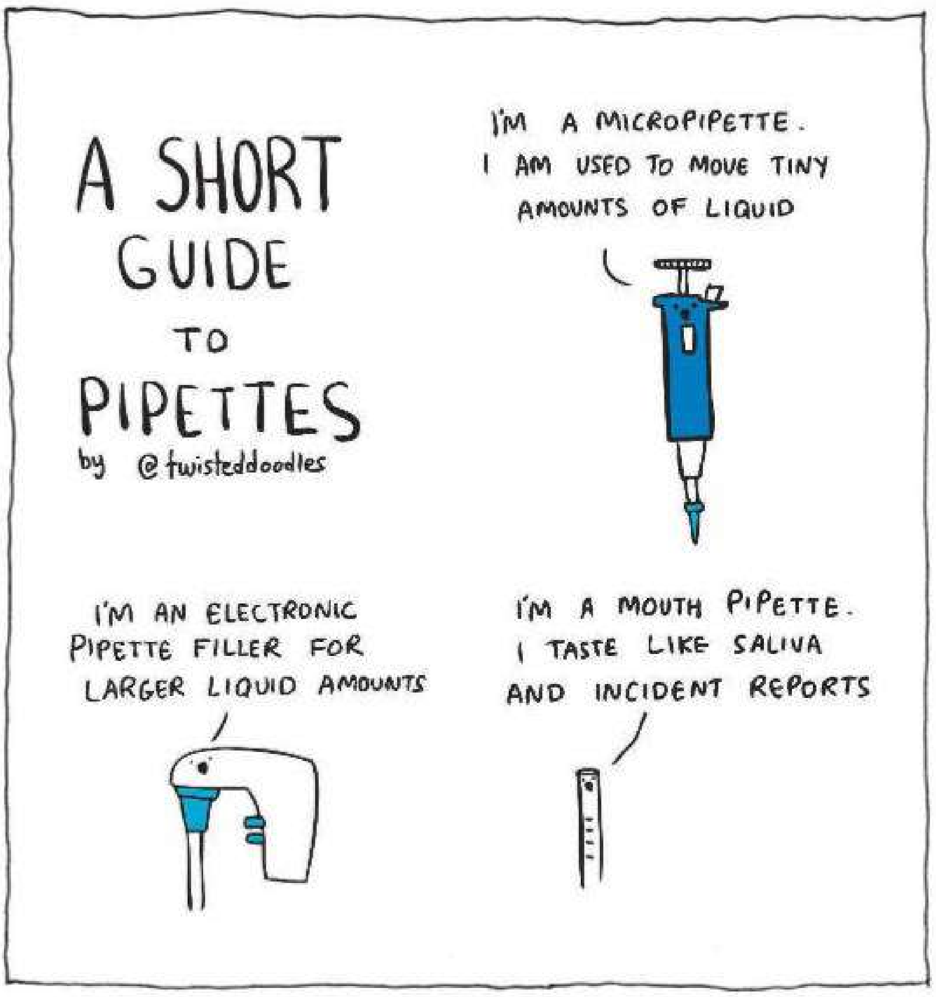
Big. Very big.

"Asteroid bigger than Carrauntoohil to soar past Earth tonight," boomed the *Irish Examiner* on 18 January, in a clipping sent by Stuart Neilson. "Named 7482 (1994 PC1), the asteroid is more than a kilometre wide at 1,052m and is just about bigger than Ireland's highest peak, Carrauntoohil which is 1,038m tall."

For those still struggling with just how big that is, never fear. "Its size means it is also bigger than the Burj Khalifa in Dubai which, at 830m, is the world's tallest building," we further read.

So pretty big, then. "Most asteroids that whizz past the Earth are about the size of a family car. They're not terribly big but this one is not the size of a family car, it's the size of Carrauntoohil," space commentator Leo Enright added helpfully. Our only open question now is how big is a family car in Burj Khalifas.

Twisteddoodles *for New Scientist*


A SHORT GUIDE TO PIPETTES
by @twisteddoodles
I'M A MICROPIPETTE. I AM USED TO MOVE TINY AMOUNTS OF LIQUID
I'M AN ELECTRONIC PIPETTE FILLER FOR LARGER LIQUID AMOUNTS
I'M A MOUTH PIPETTE. I TASTE LIKE SALIVA AND INCIDENT REPORTS

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Consideration of items sent in the post will be delayed

Mind that gravity

"Is the Hubble crisis connected with the extinction of dinosaurs?" enquires physicist Leandros Perivolaropoulos at the University of Ioannina, Greece, in a paper recently added to the arXiv preprint server, meriting an immediate induction into our pile of "questions we had not thought to ask".

To back up some 13.8 billion years: the Hubble crisis (we paraphrase, slightly) is the fact that if you look at what the universe was doing very far over there in the dim and distant, and then work out what it should be doing over here now, what it is actually doing now is different, meaning something naughty must have happened when our backs were turned.

Something like, we don't know, someone pressing a taped-over button on a control panel saying "do not touch" and inadvertently increasing the strength of gravity rather suddenly about 100 million years ago.

Stuff happens. The point is, had this increase actually occurred, it might explain the Hubble crisis and also, according to Perivolaropoulos's calculations, have discombobulated the outer solar system sufficiently to have sent a load more space rocks careering towards Earth. This might have included the one that came steaming in flying a dino skull and crossbones flag some 66 million years ago.

We like this idea, on the basis that no one is going to tell us it isn't true. And on the scale of cosmic conspiracies, this is hardly the largest. Everything is connected to everything else, after all, which is why we are going to go out on a limb and say it was actually the big bang that did for the dinosaurs.

Quantum whipping

A hop, skip and a jump across the Ionian Sea away, meanwhile, Theodore Andronikos and Michael Stefanidakis at the Ionian University on Corfu consider how a quantum parliament would work, also on the arXiv server.

Why, you may ask. The way things are going right now, we might counter: why not? Yet despite staring very hard at the paper for some time, our answer is somewhat indeterminate. The premise is replacing a system in which party loyalty dictates how legislators vote with a "free will radius" that can take any value from 0, for total loyalty, to 1, for total independence, running it through a quantum voting system and then seeing what happens.

Answer: it depends. But why stop there? What if not just quantum voting systems are employed, the authors muse, but voters, parties, politicians and bills themselves become quantum? "This is a fundamental question of a rather philosophical nature that is probably very hard to answer and, in our view, it deserves further consideration," they write. We add it to our pile of ones we never thought to ask. Or not.

Entangled thinking

The covid-jabbed may find out sooner than we thought, if US anti-vaxxer Sherri Tenpenny is to be believed, an assertion to which we prophylactically assign a classical truth value of 0. "Remember this term, because you're going to hear a lot of it in the next year: quantum entanglement," she avers in a clip circulating on Twitter. "From a physics perspective, what happens when you take that shot in? There's all this entangling that goes on, and what the artificial intelligence hooking you up to the Google credit scores and all of the dematrix and all of those things."

Not only that, Sherri, it unleashes the robot vacuum cleaners, too. If this is the best we can come up with, maybe that's not such a bad thing. ▮

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